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PROCEEDINGS OF THE WORLD SCIENTIFIC MEETING ON THE BIOLOGY OF TUNAS AND RELATED SPECIES

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1963

FAO FISHERIES REPORTS

This is the sixth in a series of reports of meetings, surveys and other activities of FAO Fisheries Division.

Other documents in this series are:

FIt/R1 (En)	Report of the international conference on fish in nutrition	1962
FIe/R2 (En)	Report on the meeting of an expert panel on fish meal and fish flour for human consumption	1962
FIe/R3	Requirements and improvements of fishery statistics in the North Atlantic area	1962
FIt/R4	Report of the FAO-EPTA regional training centre on fish processing technology, 6 March - 14 April 1961, Quezon City, Philippines (Provisional edition)	1962
FIe/R5	Report of the meeting on the economic effects of fishery regulations	1962
FIb/R6 (En)	Proceedings of the world scientific meeting on the biology of tunas and related species	1963

Unserialized reports dated earlier than January 1962 are listed in the FAO Catalogue of Fisheries Publications and Documents (1962). Certain unserialized reports may be reprinted in this series as the unserialized versions go out of print.

For the Table referred to on p. 39 under "2 Discussion" see back of Vol. I of the Proceedings.

FAO Fisheries Reports No. 6 Vol.1 FIb/R6.1(En)

PROCEEDINGS OF THE WORLD SCIENTIFIC MEETING ON THE BIOLOGY OF TUNAS AND RELATED SPECIES

La Jolla, California, U.S.A., 2-14 July 1962

Edited by

H. Rosa, Jr.
Chief, Marine Resources Section
Fisheries Biology Branch

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1963

PREPARATION OF THIS REPORT

This volume is the revised version of the Draft Report, which was distributed to the participants and to the contributors to the World Scientific Meeting on the Biology of Tunas and Related Species, in La Jolla, California, 2-14 July 1962.

The subsequent volumes of the Proceedings will contain the technical papers and a bibliography on tunas contributed to the meeting.

The views expressed in the papers and discussions are those of the contributors and participants, and not necessarily those of the Food and Agriculture Organization of the United Nations.

The following persons helped in editing the report.

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Distribution

FAO Fisheries Division
FAO Regional Fisheries Officers
Members of ACMRR
Members of continuing committee for the Facilitation of Tuna Research
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Pr 61-228me. Reports organization and objectives, general results achieved and resolutions; gives reports of section and working groups. Includes lists of officers of the meeting, participants and documents.

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I ORGANIZATION AND OBJECTIVES

Organization

At the Tenth Conference of the Food and Agriculture Organization (FAO), held in Rome, 31 October to 20 November 1959, the value of holding expert meetings on various species groups of fishes was recognized, and the Conference recorded the view that the World Scientific Meeting on the Biology of Sardines and Related Species, held in Rome the previous month, had been timely and valuable. The Conference recommended that further such meetings be convened including, specifically, one dealing with tunas, and that this should cover biological, technological and economic aspects of tuna stocks and fisheries.

Following consultation with scientists from several countries, who all agreed on the need for a meeting on the biology of tunas, bonitos and related species, it was decided to convene first a meeting to consider only the biological aspects of tuna stocks. The United States of America graciously offered to be host to the meeting and the Bureau of Commercial Fisheries of the Fish and Wildlife Service, United States Department of the Interior, and the Department of State helped with its organization. Through the generous cooperation of the Art Center in La Jolla and the La Jolla Women's Club, the premises of both institutions were made available for the meeting throughout its duration from 2 to 14 July 1962.

A group of scientists, the Consultative Group, kindly assisted FAO in planning and organizing the Meeting. The members of the Group who attended the Meeting agreed to act as members of the Steering Committee under the leadership of Mr. V.E. Brock (Chairman of the Meeting). Messrs. B. De Jager and G. Saetersdal acted there for Mr. C. du Plessis and Dr. H. Einarsson.

The meeting was organized into nine sections:

Section 1/A	Species identification and distribution: adults
Section 1/B	Species identification and distribution: larvae and eggs
Section 2	Population identification
Section 3	Size and composition of stocks
Section 4	Availability (accessibility and vulnerability)
Section 5	Physiology and behavior
Section 6	Fishing methods
Section 7	Statistics of catch and effort
Section 8	Future lines of tuna research

To each of the nine sections a part of the time of the full Meeting was allocated, and section chairmen and rapporteurs were elected.

Six working groups were organized as follows:

(1) taxonomy,
(2) blood samples,
(3) stock transfers,
(4) identification of larvae and juveniles,
(5) tagging,
(6) statistics.

Separate reports were written by groups (3) and (4). The reports of the others were incorporated in the corresponding section reports.

Members of the Consultative Group and other selected scientists were asked to produce background documents (Synopses and Methodological Papers) in advance of the Meeting. Voluntary contributions, (Experience Papers) were submitted by a number of tuna biologists and Information Papers were prepared mainly by the FAO staff.

1. Synopses on the biology of species and stocks (29)

A summary statement of facts about the taxonomy, distribution, bionomics, population characteristics and exploitation of the species, compiled according to an outline provided by FAO.

2. Methodological Papers (9)

Papers reviewing the known facts,

hypotheses and gaps in knowledge and suggesting future lines of work relevant to the major subjects of the Meeting and describing and discussing the methods employed for their investigation.

3. Experience Papers (40)

Individual contributions, dealing with results of research, information on tuna resources, aspects of biology and interpretation of data on various species of tunas in different areas.

4. Information Papers (9)

Papers containing compiled miscellaneous information of interest to the Meeting.

Nine section reports, two Working Group reports, and one report of the Meeting were drafted. Two hundred and forty-nine participants attended the Meeting, representing eighteen countries and six international organizations.

Objectives

The objectives of the Meeting were:

(1) To bring together participants from governments and private institutions engaged in studying the identity, distribution, behavior and potential yields of stocks of tunas, bonitos and related species

(2) To review and appraise:

(A) the development of tuna fisheries and their current commercial exploitation

(B) identity, distribution, behavior and potential yields of tuna stocks

(C) specific problems and outlook for future international cooperation in coordinating methods and programs of research

(D) means whereby such international action could be made possible

It was hoped that the Meeting would, under these items, make observations on the following points:

(a) the extent to which tuna resources are exploited at present

(b) the extent of danger of overexploitation of particular tuna stocks

(c) the extent to which exploitation is limited or is conducted inefficiently because of lack of knowledge of resources, inadequate control and administration, or inefficient methods and equipment

(d) the extent to which understanding of tuna resources is limited by lack of knowledge of the biology of the species, dynamics of their populations and their environment or by deficient research methods and techniques

(e) the extent to which understanding of tuna resources and fisheries is limited by lack of a uniform system for collection and exchange of statistics of catch and effort in all areas of their exploitation

(f) the kinds of programs that should be developed to remove disabilities such as those indicated under (c), (d) and (e)

(g) lines of activity to be considered under the item (D) above, such as:

(i) provision of a documentation service (bibliographies, synopses, reviews, etc.)

(ii) arrangement of regional or international meetings and symposia

(iii) exchange of information concerning programs

(iv) provision of fellowships

(v) exchange of teaching facilities

(vi) development of other contacts between tuna investigators

(vii) consideration of bodies, such as FAO and UNESCO, which could undertake international action in close cooperation with existing regional fishery organizations

II GENERAL RESULTS OF THE MEETING

Introduction

It is quite out of the question succinctly to summarize several day's deliberation of over one-hundred persons concerned with the tuna resources, and in any case these are given in some detail in the section reports, and supported in depth in the various papers prepared for the meeting. Rather, we have chosen a point of departure and attempted to highlight those portions of the proceedings most relevant to that point.

This meeting on the biology of the tunas was concerned both with the assessment of present knowledge and with the questions that may be asked of tuna biologists in the future.

With respect to a point of departure, the most obvious and dramatic aspects of the world tuna situation developed at the meeting are two: first, before us for consideration was not an unused resource, nor a resource at the terminal stages of development, but rather one in mid-stream. In recent years demand and yield have doubled approximately each decade. Current landings are approximately 800,000 tons annually and there is indication that market demand for 1,500,000 tons will exist by 1970. At least one population, the eastern Pacific Yellowfin, has now apparently reached the limit of its productivity. Indications are that other populations are responding to fishing in a predictable manner. This exponentially expanding demand on what must be a finite resource, will soon be the central biological problem before tuna scientists, though at the moment the world-wide central problem appears to be the development of a more complete understanding of tuna ecology and behavior, leading toward more efficient utilization of this valuable resource.

The second salient feature of this resource is its international character. Except whales, no other major, currently utilized fishery resource shares this character in such a spectacular way. Most of the tunas live in international waters, and modern fishing techniques and the modern means of distributing the product places no group of people in a favored position, except for very special situations. Tuna scientists around the world, then, must share global responsibilities for providing the scientific basis for the full and wise use of the tuna and tuna-like fishes.

Thus, during the preparation of this report, we faced this question: anticipating the demand for tuna and recognizing world ownership, is the present rate of increment to our knowledge rapid enough to ensure orderly and full use of the resource? We have here attempted insofar as the meeting has provided guidelines, to indicate areas in which research seems to require either acceleration or changes in direction, or both.

Species Identification and Distribution

Adults

Because of the vital role of tunas and mackerels in world fisheries, their taxonomy must be firmly established to co-ordinate the collection and analysis of adequate statistical data for catch and effort on an international basis.

Apparently only relatively minor differences of opinion exist with regard to the classification of scombrid fishes down to the generic level, and there is good agreement on the species of "major" tunas. Differences are mainly concerned with species and sub-species of "minor" tunas. In this field the need for international cooperation cannot be overemphasized, so that there can be early definition of the basic biological units and so that name-changing will not further complicate the accumulation of data on the various members of the family.

Specialists active in this field should have access to suitable material collected from all areas of the geographical distribution of the species concerned. Financial support would be necessary to facilitate the expensive task of shipping and housing at selected centers the material which would be collected on a world-wide basis from institutions and organizations actively engaged in tuna research.

Eggs and Larvae

The identification of the eggs and larvae is extremely difficult but highly significant in relation to spawning

studies and the subsequent assessment of the larval survival and mortality rates. The determination of the interrelation of physical, chemical and biological factors associated with spawning areas will be extremely useful in explaining the success or failure of year classes.

Our present knowledge of tuna eggs and larvae is not adequate to permit the certain identification of those of several important species, and further research is urgently needed to remedy this deficiency. In addition, standardization of collecting methods, cooperative cruises, and the rapid exchange of materials and information will furnish a basis, providing the problems of identification are solved, for delineating spawning areas, seasons, and possible spawning success. A concerted effort should also be made to obtain collections from expeditions not primarily concerned with tunas, for example, the scheduled International Indian Ocean Expedition.

Population Identification

The nature of the tuna fisheries and the trend of increasing world yield make the problem of population identification urgent.

Two classical methods have been widely applied to tunas; the study of body proportions and tagging. A recent method involves the study of blood group systems by immunological techniques. These methods endeavour to establish the natural sub-divisions of the population, i.e., natural groups showing significant but unassessed heterogeneity. These are the basic units that should be defined so that unit stocks may be meaningfully identified. Another approach would be to consider the various populations with reference to vital parameters such as growth and mortality which, of course, includes the effects of the different fisheries. One advantage of this approach is the inclusion of the effect of the fishery as one of the defining parameters. A serious disadvantage of this approach is that it does not permit ready explanation or prediction of the effects of geographical changes in the fishing pattern or the major redistribution of the stocks themselves. It appears, therefore, that even if this pragmatic approach gives satisfactory results in an operational sense, it is well to learn the biological units within each species.

Although a promising start has been made on the identification of tuna subpopulations, the main task of identification and range delimitation lies ahead and these problems are relevant to all tuna species in all oceans. Techniques must be selected to determine the rate of mixing and total amount of mixing; natural characteristics that could serve as natural tags must be studied.

To achieve the tasks of the identification of tuna subpopulations and range delimitation, methodology will have to be improved, which must include the development of new methods or the adoption of methods being used in other fields.

Cooperation among all nations concerned with tuna resources in relation to tagging programs, the supply of blood samples to a central facility and to the study of the relationship of populations to specific water masses and current systems is highly desirable and should be practical to implement.

Size and Composition of Stocks

The rapid growth of the tuna fisheries during the last decade and the anticipated increase over the next decade places particular emphasis on the study of the size and composition of stocks which are subjected to exploitation on a world-wide basis. The magnitude of tuna stocks and their rates of replenishment will provide an upper limit to the magnitude of yields from the tuna fisheries. The effects of a fishery on a population, that is, a change in the abundance and in the age and size composition of the population, are observed by studying the variations in estimates of population size and the examination of the size composition of the catch.

The effects of a single fishery on a single population were shown in the case of the yellowfin tuna in the eastern Pacific and it was clearly evident that this population showed signs of reaching the limit of its productivity. It has been equally clearly shown that the skipjack in this same region can support a greatly increased fishery. Due to the number of stocks involved in the expanding world tuna fisheries it is vital that similar studies be undertaken for all species in all important tuna fishing areas.

Methods employed to determine maximum sustainable yield must be standardized to be used on an international basis. Once this is achieved, it will be possible to have comparable data where different fisheries exploit the same species and possibly the same population.

Availability (Accessibility and Vulnerability)

Broad investigations of the relationships between tunas and their oceanic environment have been carried out by the American and Japanese research organizations in the Pacific Ocean. These were done in relation to sea-surface temperatures, to food supply and the association of tunas with specific water masses. Environmental studies of this nature are needed in other ocean regions, e.g., the eastern Atlantic and the Indo-Pacific. The study of the Indian Ocean on an international basis may explain many oceanic features such as circulation, productivity, etc., in relation to the occurrence of tunas and other related natural resources in this area.

Environmental studies of the regional coastal areas in which tuna fisheries are conducted must be studied in great detail in order to explain the uneven distribution of species and the reason for their tendency to concentrate in certain specific areas. Behavior studies in relation to feeding, spawning, migration and fishing gear must be accelerated.

The need for temporal studies of the environment and the coupling of oceanographic and meteorological research is of primary importance. The serious lack of research tools such as vessels and equipment in certain regions of the world will restrict internationally-conducted research efforts to a certain degree.

A much greater understanding of the oceans of the world is needed not only in explaining the fluctuations in the availability of tunas, but also in relation to all the natural resources of the sea, and the commerce of the sea. Thus the suggested research need not be justified on the basis of the economic value of tunas or on man's intellectual curiosity about them.

Tuna Behavior and Physiology

The rationale of acquiring knowledge of the behavior and physiology of tunas tends to fall in two parts. In the first, we are intensely concerned with the patterns of distribution and abundance of tunas in relation to the patterns in the environment. Hopefully, the goal of first predicting changes in the environment through studies of meteorology and oceanography, and from these forecasting changes in the abundance and distribution of tunas will be achieved. Without knowledge of the behavior and physiology of tunas, it will be impossible to predict with cause-effect certainty the responses of the tuna populations, though pragmatically developed useful associations may be developed from time to time. Put another way, we need to know how tunas practice oceanography, what they measure, and how they react to their measurements so we may conduct our measurements meaningfully.

The second need for behavior and physiology lies in the area of effectively harvesting the resource, the development of fishing techniques. To date, these have all originated from fishermen who have employed their own technological knowledge with their experience and their emperical knowledge of behavior. Though phenomenally successful in this endeavor, it is clear that there are large numbers of tunas throughout the world that are not vulnerable to any harvest technique now known on a practical scale.

There is on hand a well-developed body of ethological and physiological theory and general methodology. Much of it has developed from studies on fishes. The dearth of information on tunas can be ascribed to lack of scientific effort on these forms and this can largely be ascribed to the difficulty of handling tunas under controlled conditions, and of directly observing them at sea, i.e., lack of the required special facilities, except for the types of facilities available to commercial fishermen.

Consonant with these observations, it is apparent from the documents of this meeting that such knowledge as is on hand stems largely from scientific observations on commercial fishing observations, an approach with obvious limitations, preliminary results from observing tunas captive in crude holding facilities, and preliminary observation obtained from

the first underwater observing facilities (underwater parts in research vessels).

Obviously the presently existing facilities are suitable only for a limited spectrum of experimental and field observation, both of which must interact and keep properly apace if a useful body of information is to develop. Eventually very expensive facilities will be required. Because of the expense, and because of the world-wide distribution of tunas together with presumed universality of the behavior and physiology of tunas, it seems logical to suggest this as an area for international cooperation; perhaps in the form of the establishment of a cooperative world-wide center for the study of the behavior of large pelagic fishes.

Fishing Techniques

The commercial capture of tunas is dependent on exploiting either their movement or their aggregation together with feeding or other responses to the feeling gear. Trapping and gillnetting are examples of methods exploiting the movement of tunas, though the longline is the most spectacular of this class. Methods of fishing aggregations of tunas are trolling, live bait fishing, pole and line fishing, and purse-seining with the degree of aggregation tending to increase in that order. In terms of importance, longlining, purse-seining, live bait fishing, and trolling supply most of the world's catches.

The existing fishing techniques have been developed by fishermen with little help from science excepting as science has provided new and better materials, engines, etc. It seems quite likely that as science improves on the ways of locating tunas and provides further increments to the knowledge of the behavior of tunas, these developments will also be incorporated into capture methodology by the fishermen.

Fishing techniques are difficult to separate from the problem of meeting the market demand for tunas at an economical price. It was advanced at the conference that increased tuna landings in the immediate future will come, not from expansion of the long-range fleets, e.g. longliners, purse-seiners, tuna clippers, but mainly from the development of local fisheries taking advantage of situations most economically exploitable from small, locally-based vessels, and perhaps using to a proportionally greater extent the minor species of tuna-like fishes. (The present ability to store and ship tuna cheaply makes such small-scale local production competitive). It appears that modification and adaption of existing fishing techniques will provide a sufficient basis for these fisheries. It was recognized, nevertheless, that long-range high seas fleets will maintain and increase their importance in world tuna production.

The remaining obvious unused resource is the mid-ocean population of fishes not susceptable to harvest by longline, for example, the skipjack. One cannot even speculate realistically on how these can be harvested. The results of ecological, behavioral, and physiological studies appear to offer the only hope of making these resources accessible.

Statistics of Catch and Effort

Statistics of catch and effort are useful for research of several kinds: (a) measurement of changes in abundance in space and time; (b) investigation of the success of fishermen in locating the best concentrations of tunas; (c) research on population dynamics; (d) elucidation of such biological problems as migrations, etc. Areas of the ocean that are adequately reported upon are the exception rather than the rule. Examples of such areas are the west coasts of North and Central America. Additional material on the use of such statistics is given in the discussion of size and composition of the stocks.

Several of the world tuna populations on which substantial fisheries are based, and for which catch records are available, show measurable effects of the additional mortality imposed by the fishery. In the light of the projected doubling of world demand over the next decade it seems imperative that adequate reporting begin at the earliest possible moment for three reasons: (1) at least ten years of records are needed to estimate adequately such quantities as maximum sustainable yield; (2) information on the condition of the virgin stocks,

irretrievably missing in most instances, is of immeasurable value in understanding the dynamics of fished populations; and, (3) because the resources properly belong to all the world's people those using them are under a moral obligation publicly to report their activities.

Future Research Planning

Much of the material developed in this section has already been incorporated in the report. Many ideas superficially peripheral to the biological theme of the meeting were advanced and are worthy of note. Perhaps highlighting this class of ideas is the need at least to consider the economic implications of fishing restrictions, even though the biological effects receive paramount consideration. The latter, as was pointed out, are usually singled out for primary consideration because maximum sustainable yield is a property of the population of fish; it can be measured, and it is not subject to the vagaries of human values.

III RESOLUTIONS[1/]

RESOLUTION 1

The Systematics of Tuna and Related Species

The Meeting,

Notes that the papers by Collette (1961)[2/] and Collette and Gibbs (Methodological Paper 1A in Report of Section 1/A) have filled the need for a preliminary review of tuna systematics expressed at the Dakar Symposium and that the latter paper answers the specific request made by the Honolulu Conference;

Observes that the species of the genus *Euthynnus* are still in need of revision as stated at the Dakar Symposium;

Takes note of the recommendation of the Mandapam Camp Symposium for international effort for a review of scombroid fishes on a world-wide basis;

Notes the confusion caused by the use of numerous different generic and specific names in different parts of the world already considered during the regional tuna meetings at Dakar, Honolulu, and Mandapam Camp, and as exemplified by the papers presented at this meeting;

Points out the need for work on large scale collections of scombroid fishes from all over the world to solve the systematic problems in these wide-ranging species and genera and the difficulty and expense both of gathering and housing such collections;

Suggests that Methodological Paper 1A by B.B. Collette and R.H. Gibbs, Jr., be used as a tentative outline of scombroid systematics for the stabilization of the nomenclature of the group on a world-wide basis;

Further suggests that the thirteen generic names within the family Scombridae and the six species names within the genus *Thunnus* as utilized in Methodological Paper 1A be tentatively accepted pending future revisionary studies;

Recommends that a few major centers with adequate manpower, storage and library facilities be selected for the accumulation of the necessary specimens, to make possible the examination of world-wide material by interested research workers;

Recommends further that among such selected centers there should be included the U.S. National Museum, Washington, the Muséum National d'Histoire Naturelle, Paris, and Fisheries Department of Kyoto University, Japan. These three centers are recommended because, in addition to the prerequisites mentioned above, in the case of the U.S. National Museum there will be two systematists actively working on scombroid fishes; in the second case, a European area is geographically desirable, and the Museum d'Histoire Naturelle has the most important existing collection of scombroid type material; in the third case, Kyoto University is in an especially advantageous position for obtaining material from all parts of the world ocean.

Calls attention to the fact that such selected centers would be of far greater value if adequate financial support were provided to facilitate the expensive task of shipping and housing such material;

Requests aid in gathering this material on a world-wide basis from institutions and organizations interested in scombroids.

1/ For information on Dakar and Mandapam Camp Symposia and Honolulu Conference see Appendix 1

2/ Collette, B.B., 1961 A preliminary review of the tunas of the genus *Thunnus*, unpubl. Paper No.VI-1, Pacific Tuna Biology Conference, Honolulu, Aug. 1961, 30 p. Abstract in: Spec.sci.Rep.U.S.Fish Wildl.Serv. Fish., (415):24

Points out that in addition to the collection of material at the above noted centers travel is essential both for workers wishing to visit such centers, and for workers at these centers needing to examine larger series of material at other critical areas;

Recommends that appropriate authorities explore sources of funds sufficient for conducting and concluding these studies as soon as is possible, with a view to completing a definitive monograph on this group of fishes with all species illustrated in color.

RESOLUTION 2

Definition of Populations by Blood Typing

The Meeting,

Recognizing the importance of the contribution that population genetics can make to the identification and delineation of tuna populations;

Urges that existing studies in this field be vigorously pursued and that such studies be extended where possible to include additional species of importance to the present meeting;

Recommends that there be established a Tuna Blood Group Center to promote the exchange of tuna erythrocytes, reagents for the typing of tuna bloods, and information on tuna blood group research and that the Bureau of Commercial Fisheries Biological Laboratory at Honolulu continue to act in that capacity; and

Adopts the report on nomenclature arising from the Honolulu Conference, to wit:

"1) It was argued and agreed that the bulk of nomenclatural problems could best be solved not by adopting hard and fast rules as to what symbols to use but by agreeing to use a standard form of typesetting rules to set the symbols devised by the author.

"It was agreed:

"2) That the author had the prerogative of changing his symbols if he desired but that he was in no way bound to do so.

"3) That phenotype designations be set in bold face type, preferably Roman Bold Face, and that regular subtyping relationships be designated by a subscript number. Thus, if numbers are used as designators of a blood factor and not as denoting a subtyping relationship, they also shall be set in Roman Bold Face Type.

"4) That symbols for alleles shall be set in italics. *Jul*, $/Ju2_2$; *C/c*, *c/c*.

"5) That reagents recognizing antigens known to belong to a blood group system be reported by systems having a common letter or two-letter designation. Ju, C, A, etc.

"6) That blood factors may be designated by numbers (1, 2, etc.) or letters (A, B, Y', E', X) remembering that regular subtyping be designated by subscripts Jul_1, Jul_2; E'_1, E'_2, E'_3; etc.

"7) That when the cross reactions of different specimens are so similar as to indicate some high degree of homology similar letter designations be made followed by a species identification, such as the Tg system of albacore, or Tg 1.3 (bigeye), Ju2 (8 in back), Jul_2 (sperm), or by some appropriate code introduced in the introductory statement of the paper but not by Tg 1 (meaning the 1 antigen of albacore) and BE1 (meaning the 1 antigen of bigeye), when these two antigens are clearly and closely related by overlapping serological cross reactions."

RESOLUTION 3

Definition of Populations in the Indian Ocean Area

The Meeting,

Viewing the importance of the tuna resources of the Indian Ocean and the opportunity afforded for the study of these resources by the International Indian Ocean Expedition;

Recognizing the recommendations of the Mandapam Camp Symposium that "the system of defining the homogeneous stocks of different tuna species, particularly by blood typing as being developed by Japanese and American workers be extended to a thorough coverage of the tunas and bill fishes of the Indian Ocean";

Urges that this recommended program be given vigorous support by participants in the International Indian Ocean Expedition; and

Suggests that the Centre of Biological Works to be established at Cochin, India, act in full cooperation with the Tuna Blood Group Center in Honolulu to facilitate the collection and shipment of blood samples collected in connection with the International Indian Ocean Expedition.

RESOLUTION 4

Multi-disciplinary Attack on Taxonomic Problems

The Meeting,

Recognizing that a multi-disciplinary attack by immunogeneticists, biochemists, classical taxonomists and others upon taxonomic problems of importance to the study of tunas and related species would be fruitful and produce valuable contributions in this field of research;

Recommends that a working group be formed to select a particular taxonomic problem following recommendations developed through correspondence with interested parties.

RESOLUTION 5

International Tuna Tagging Programs

The Meeting,

Being aware of the value of fish-tagging as a means of obtaining information on: (1) growth, (2) movement and migrations, (3) stock identity, and (4) certain vital statistics of population;

Recognizing that there are areas and species for which at present there are no, or insufficient, tagging programs, although current research programs stand in need of the kind of information that tagging could furnish;

Believing, moreover, that some improvements could be effected in: (1) tags and techniques of application, (2) design of tagging programs, (3) arrangements for recovery of tags, and (4) the theory of interpretation of results; and

Believing also that the possibility of improvements of these kinds would become readily apparent and that means of devising such improvements and of putting them into effect could be accomplished most rapidly and effectively through international collaboration, especially by effective exchange of information on plans for, and results from, tagging programs;

Recommends that among the responsibilities of the proposed continuing Committee on tuna research, should be included the task of promoting international action along the preceding lines, including the compilation and publication of an annual inventory of tagging programs.

RESOLUTION 6

Collection, Collation and Dissemination of Catch and Effort Statistics

The Meeting,

Noting that the tuna fisheries have expanded to world-wide proportions during the past decade, and that these fisheries are still expanding rapidly and will shortly be drawing upon all available tuna stocks;

Observing that the intensity of fishing on some stocks is increasing to critical levels with the expansion of the fisheries;

Having concluded that accurate records of total catch as well as of catch and corresponding fishing effort are essential to understand the relationships between the fisheries and the fish populations they utilize; and

Noting that many such records are presently both incomplete and inaccurate and in most regions are not being gathered or made available in a compatible form in a timely fashion;

Recommends

1. That a uniform system of reporting total catch and catch per unit of fishing effort on all species of tuna wherever caught should be developed for use by all nations participating in these fisheries.

2. That accurate records should be kept for each gear type by weight of total catch of each species of tuna and of other species taken at the same time, geographically as far as possible in five degree areas of latitude and longitude or, when such accurate locations are not available, to be identified with larger geographic areas within which the smaller geographical units can be grouped, but that such larger areas should not be larger than the area of distribution of unit populations.

3. Estimates should be made of the effort expended in taking the catches referred to in item 2; for this purpose log book records of effort and associated catch by species, by weight (and where possible by numbers), from representative samples of the fishing fleets should be used; these records should be compiled in one degree areas of latitude and longitude for each month.

4. That the log book records should be classified by gear type and by vessel size or other characteristics associated with fishing power, or be standardized before reporting, provided a detailed description of the method of standardization is published with the data.

5. That all data concerning total catch and log book records of catch and fishing effort should be compiled by the month of catch so far as possible.

6. That each nation should develop these records from its own fleets and compile and distribute the monthly records after the end of each quarter (using January, February, and March as the first quarter, etc.), issuing preliminary reports to all other interested nations and organizations as soon as practicable after the end of each quarter.

Requests

1. The Food and Agriculture Organization of the United Nations to assume responsibility for coordinating and developing such records, assisting nations which require help in developing their methods of recording and reporting data, providing continuing review to insure world-wide uniformity and accuracy of the data, and promoting rapid distribution of the preliminary quarterly reports.

2. The Food and Agriculture Organization of the United Nations to compile and publish, on an

annual basis, summaries of these data from all countries, including all corrections and additions to the preliminary quarterly reports.

RESOLUTION 7

Standardization of Gear and Methods for Collecting Embryonic, Larval and Juvenile Tunas and Related Species

The Meeting,

Aware that knowledge of the occurrence and distribution of embryonic, larval, and juvenile tunas is still very incomplete for most species and in several major sectors of the world ocean;

Cognizant of the essential nature of information on the early life history of these fishes to an understanding of the varying abundance and distribution of the adults;

Realizing that performance characteristics of presently employed collecting gears are poorly known, and that ideal instruments for quantitatively sampling the early life stages of tunas, particularly the juveniles, are not presently available;

Bearing in mind that several international oceanographic expeditions, such as the International Indian Ocean Expedition and the International Cooperative Investigations of the Tropical Atlantic, as well as surveys elsewhere in the world ocean that are being planned for the near future, such as the Cooperative Program of Research in the Eastern Tropical Pacific Ocean, will provide extensive opportunities for the collection of tuna larvae and juveniles;

Calls attention to the need for studies on the performance characteristics and catching ability of presently used gears and to the immediate urgency of developing new and improved instruments for the quantitative collection of tuna larvae and juveniles as well as the standardization of methods of using these gears so as to yield quantitatively comparable results; and,

Recommends that, until such improved sampling devices are available, there be selected and adopted as standard procedure for use on each cooperative and joint international oceanographic expedition the best of the currently available sampling gears and methods, and that these be used in uniform manner by participating agencies in addition to the necessary development and use of other special gears and methods.

Recommends further that the microdistribution of eggs and larvae be studied so that the proper models for statistical estimation may be devised.

RESOLUTION 8

Study of Survival of Larvae

The Meeting,

Recognizing the key role which fluctuation in larval survival plays in producing tunas of sizes useful to man;

Bearing in mind that research on the effects of environmental factors on survival of organisms can be accomplished most effectively in the laboratory where such factors can be controlled;

Noting that this is presently not possible with tuna larvae owing to lack of knowledge and inadequacy of facilities;

Draws attention to the high desirability of perfecting techniques of rearing tuna larvae in the laboratory so that such studies can be initiated and,

Recommends that appropriate authorities explore the possibility of establishing a center with adequate facilities and competent personnel where embryologists, physiologists, biochemists, and scientists in related experimental fields can undertake the required research under conditions conducive to satisfactory results

RESOLUTION 9

World-Wide Study of Tuna Eggs, Larvae, and Juveniles

The Meeting,

Having received the report of section 1B on the species identification and distribution of the larvae and eggs of tunas and related species;

Being aware of the vital nature of studies in this field to several aspects of tuna research;

Knowing that the wide-ranging nature of the species under study render difficult the understanding of these factors from localized study;

Recommends that a working group of scientists engaged in this field of research be established to study, by correspondence, the proper way of coordinating and extending studies in this field on a world-wide basis.

RESOLUTION 10

Cooperative Study of Albacore (*Thunnus alalunga*) and Bluefin Tuna (*Thunnus thynnus*) in the North Pacific Ocean

The Meeting,

Aware of the urgent need for cooperative research and exchange of data among persons and organizations throughout the world in order to assess and to monitor the condition of the several species of tuna and particular stocks thereof in the ocean;

Noting, in particular, that scientists agree that the North Pacific Ocean supports only one population of albacore and may support only one population of bluefin, and that these species range over this ocean area and are fished predominantly by Japan and the United States;

Noting further that fishermen of these nations are carrying out their operations in different portions of the migratory route of these species and that the scientists of the respective nations, studying the population dynamics, life history, and ecology of these species, are similarly collecting and analyzing data from only parts of their geographic range;

Realizing that a complete and useful understanding of the life history, ecology, and population dynamics of the North Pacific albacore and bluefin can be facilitated by obtaining necessary observations during various available stages of their life history and consequently from different places along their migratory routes, and that this also requires the exchange and pooling of presently available scientific data relating to these species;

Realizing also that the North Pacific albacore and bluefin populations are being fished at substantial and increasing rates and that the needed integration of research has not yet been accomplished;

Believing that the scientists of Japan and the United States could quickly integrate their substantial research efforts and findings on these species;

Suggests that appropriate authorities of Japan and the United States initiate action for the purpose of exchanging and standardizing historical current and future data on the albacore and bluefin of the North Pacific with a view to integrating their research on these species by:

1. The standardization and regular exchange of catch statistics in accordance with Resolution 6;

2. The regular exchange of age and growth data, including length frequency data;

3. The reconciliation of ageing methods for albacore and the establishment of ageing methods for bluefin;

4. The initiation of joint tagging experiments in accordance with Resolution 5;

5. The extension of present studies in the field of blood groups of albacore and to initiate such studies on bluefin tunas;

6. Further cooperative oceanographic surveys of the North Pacific Ocean such as the NORPAC and EQUAPAC Expeditions, for the purpose of obtaining synoptic coverage preferably at all four seasons of the year;

7. The expansion of means of monitoring the oceanic and atmospheric environment of the North Pacific Ocean;

8. The establishment of a small working group of Japanese and United States scientists engaged in tuna research and oceanography to meet at suitable intervals for the purpose of coordinating research efforts.

RESOLUTION 11

Tuna Oceanography in the Indian Ocean

The Meeting,

Having regard to the paucity of knowledge in the Indian Ocean area on the relation of variations in the oceanic environment to the occurrence of harvestable aggregations of scombroid fishes;

Being aware of the need for additional protein in the diets of the peoples living in countries around the Indian Ocean and the part that increased production of fish in that area might have in relieving that need;

Cognizant of the large resources of money, research-ship time and scientific personnel being employed cooperatively by twenty-seven countries in exploring scientifically the Indian Ocean during the International Indian Ocean Expedition, and the relative ease with which allotment of a small amount of that great effort toward obtaining further fishery-useful information might be made toward the solution of these problems;

Recognizing the considerable high-seas fishery oceanic research being conducted in the Indian Ocean simultaneously by Japanese fishery research laboratories which could readily be coordinated with the International Indian Ocean Expedition; and

Taking note of the similar resolution arising from the Mandapam Camp Symposium;

Recommends that the authorities involved with the planning of the International Indian Ocean Expedition should include the gathering and collating of such fishery-useful information in the course of its other studies, as the following:

(1) Surface temperature charts on a monthly basis particularly from 20° South Latitude to the continent and the island chains on the north;

(2) Variation in depth of the mixed layer with monsoon change, particularly within 200 miles of land in the Andaman Sea, Bay of Bengal, Arabian Sea, Persian Gulf and Gulf of Aden;

(3) Variation in direction and flow of the surface currents in the Indian Ocean, particularly north of 20° South Latitude, and as related to variation in monsoon period and strength;

(4) Variation in space and time primary productivity in the area north of 20° South Latitude and particularly within 200 miles of shore and submerged banks;

(5) Relation of variation in these parameters to seasonal variation in the aggregation of and in the yield from, the scombroid resources of the area; and

(6) Relation of variation in these parameters to variation in the distribution and abundance of the embryonic and larval stages of scombroid fishes in the area north of 20° South Latitude.

RESOLUTION 12

Relation of Tuna Research to Ocean-Wide Surveys

The Meeting,

Having considered the broad range of ocean surveys being contemplated by nations and groups of nations as set forth in Resolution 3 of the first meeting of the Intergovernmental Oceanographic Commission;

Cognizant of the instructions given by that Commission in that resolution to its Secretary to initiate the preparation of a comprehensive program for world ocean study through the most effective means he deems appropriate;

Aware that the wide-ranging characteristics of the tunas render their complete study possible only through such broad surveys of the circulation of the ocean and the distribution of biological, physical and chemical properties in it;

Knowledgeable also of the need for specialized studies of smaller scale oceanic features in relation to tuna ecology and reproductive potential;

Recognizing, in particular, the need for studies relating the occurrence and distribution of tunas to the effects of thermal domes, islands, temporal variations in oceanic conditions, variation in monsoon and trade wind force and direction, and similar factors;

Being informed of the possible relationships of long-term fluctuations and interrelated mechanisms of oceanic climate and the tuna populations; and

Realizing that the tuna populations are intimately related to broad-scale changes in their environment;

Recommends that the Intergovernmental Oceanographic Commission be informed of these matters with a view to including, in the international programs and expeditions organized under its cognizance, where possible, appropriate activities relating variations in the occurrence and distribution of tuna populations to environment variations.

RESOLUTION 13

Facilities for Behavior Research

The Meeting,

Noting the importance of studies of the behavior of tunas;

Noting the start which has been made in providing facilities for such studies and in pursuing such studies;

Realizing that many behavioral studies, especially of an advanced nature, will not be possible without expensive facilities for experimental research, and that such facilities are not likely to be duplicated in many places;

Urges that the appropriate authorities consider the establishment of such facilities at sites where tunas are readily available and on a scale to accommodate investigators from other research centers.

RESOLUTION 14

Research on Size Selectivity of Fishing Gears

The Meeting,

Noting the importance of being able to control the minimum capture size of fish in order to insure a rational exploitation of stocks that are intensively fished;

Urges that studies be conducted concerning the size-selective processes in the various types of tuna fishing.

RESOLUTION 15

West African Tuna Commission

The Meeting,

Considering the increasing economic importance of tunas and related species in all the seas where they are found;

Recognizing the urgent necessity of undertaking thorough studies in order to obtain a better understanding of their biology and, consequently, a more rational utilization of their populations;

Noting the remarkable results obtained in this field by the Inter-American Tropical Tuna Commission;

Concluding, therefore, that such regional organizations can be extremely useful, even within the framework of generalized world-wide research;

The Meeting

1) Suggests that the example set by the Inter-American Tropical Tuna Commission be followed elsewhere;

2) Endorses, therefore, with satisfaction, Recommendation No. 16 of the Dakar Symposium with respect to the creation of a similar commission to cover the populations of tunas being fished in the Atlantic off Africa;

3) Strongly urges the Secretary-General of the CCTA to explore all means which may lead to the creation of such a commission;

4) Expresses its appreciation to the Secretary-General of the Commission for Technical Cooperation in Africa south of the Sahara (CCTA) for the actions he has taken in this respect;

5) Asks the Director-General of the Food and Agriculture Organization of the United Nations to call together, at his earliest convenience, the planned Conference to deal with the matter on a diplomatic level.

RESOLUTION 16

Research on Economic Effects of Regulations on the Tuna Fisheries

The Meeting,

Noting that the continuing expansion of the tuna fisheries raises the possibility that conservation measures may be required, and that such measures may have profound effects on the economic efficiency of the tuna industries;

Noting that the economic health of the tuna fisheries is intimately affected by technological development in vessels and gear;

Considering that neither the specific types of economic statistics required to evaluate these effects nor the framework of theory to deal with the complex international tuna fishery are now available;

Considering that the impact of modern high seas tuna operations on the fishing industries and local economics of developing nations requires further study, and

Considering that it would be very useful to bring together a group of experts in population dynamics and economics to examine such matters.

Recommends

That the Director-General of the Food and Agriculture Organization of the United Nations consider the possibility of convening a joint meeting of experts in fishery dynamics and experts in economic aspects of the world tuna fisheries,

That such a meeting should develop uniform methods of reporting, recording and publishing statistics required to evaluate the economic performance of the tuna fisheries on a continuing basis, and

That it devote special attention to economic analysis of alternative types of conservation measures which might be considered in particular sectors of the tuna fisheries.

RESOLUTION 17

Exchange of Scientists

The Meeting,

Having received recommendations on this subject from previous regional tuna meetings;

Considering the world-wide nature of both the tunas and research upon them, and the difficulties attendant to the efficient and timely exchange of information, ideas and understanding among scientists in widely separated laboratories;

Being aware of the difficulties and expense of regional and world-wide conferences, as valuable as these have been in stimulating progress in tuna research;

Calls attention to the high desirability of exchanging scientists between institutions and nations, particularly where visiting investigators are willing and able to participate for reasonably long periods in the theoretical or practical work of the host institution or nation; and

Recommends the establishment of graduate and post-doctorate fellowships to attract and support promising biologists to fishery science.

RESOLUTION 18

Species Synopses

The Meeting,

Having considered with interest the set of 29 Species Synopses presented as background documentation;

Having taken into account that these documents are useful as a means of systematizing and presenting in readily accessible form the established facts concerning each species and that the synopses can be very helpful to meetings such as this,

Recommends to the Director-General of the Food and Agriculture Organization of the United Nations:

1. that the program of preparing Species Synopses be fully prosecuted,

2. that synopses should be prepared and distributed sometime in advance of future meetings similar to the present to enable contributors to those meetings to make use of them in preparing other types of required documentation,

3. that means be made available for preparation of synopses, especially those required for meetings such as the present,

4. that further work needs to be done to clarify and systematize the existing instructions for preparation of synopses, and,

5. that the voluntary cooperation of persons be enlisted to assist the Food and Agriculture Organization of the United Nations in the work described in points 3 and 4.

RESOLUTION 19

Provision for Continuing Committee

The Meeting,

Having considered the existing state of scientific knowledge and understanding concerning the biology of the tunas and related species on a world-wide basis;

Having taken into account the results of previous regional meetings concurrent with the biology of the species supporting these rapidly increasing fisheries, held in Dakar, Honolulu and Mandapam Camp;

Discerning the continuing need for increased liaison between scientists and laboratories conducting research on these subjects to the end of achieving better compatibility and completeness of data,

uniformity of methodology, inter-calibration of instruments and exchange of information and workers between laboratories;

Being aware of the need for identifying critical problems and stimulating research on them, and where necessary, facilitating cooperation in their solution;

Being convinced that a continuing means should be provided to achieve these ends, particularly as expressed in the resolutions of this meeting;

Invites the Director-General of the Food and Agriculture Organization of the United Nations to take steps consistent with the constitutional responsibilities and powers of his Organization to promote implementation of the resolutions of this meeting, and

Suggests that he explore with Governments the desirability of setting up a special committee to facilitate the implementation of the resolutions of this Meeting. Such a committee should, in the view of the Meeting, be small (of about fifteen members) and composed of scientists who would act in their individual capacities.

Requests further that a Secretariat for the Committee be furnished by FAO which could assist the Chairman and the Committee, for instance, by acting as a central point of communication when needed and as a point of dissemination through appropriate channels of the results achieved by the Committee, and which would further take such steps, pursuant to recommendations of the Committee, as might be necessary to insure the effectiveness of the Committee's work.

RESOLUTION 20

Absence of Professor Michitaka Uda

The Meeting,

Regrets that Professor Michitaka Uda of the Tokyo University of Fisheries, Japan, has been unable to attend.

RESOLUTION 21

The Meeting,

Expresses its appreciation to the Director-General of the Food and Agriculture Organization of the United Nations, the staff of the Meeting, the Local Committee and appropriate officials of the United States, State of California, San Diego and La Jolla as well as to the Art Center of La Jolla for calling the Meeting, for the excellent facilities provided, and for the efficient manner in which the Meeting was planned and conducted.

RESOLUTION 22

The Meeting,

Recognizing the progress made in recent years in developing theories of the behavior of fish populations under exploitation, and statistical and other techniques for treatment of data in conformity with those theories,

Recognizing the use already made of such theories and techniques in tuna research,

Believing that further development of such work is desirable, draws the attention of those engaged in tuna research to the several recommendations obtained in the Report of Section 3 of this meeting,

Recommends that among the responsibilities of the proposed continuing Committee for tuna research facilitation should be included the task of promoting appropriate international action in conformity with those recommendations.

RESOLUTION 23

The Meeting,

Expresses its appreciation of the very generous hospitality extended to its members, corporately and individually, during the course of this meeting,

And requests the Chairman to convey this expression to the several organizations, listed below:

Members of the Board, La Jolla Art Center
La Jolla Federal Savings and Loan Association
La Jolla Town Council
La Jolla Journal
Van Camp Sea Food Co., Inc.
Star-Kist Foods, Inc.
Westgate California Corporation
San Diego Tourist and Convention Bureau
Shell Oil Company
Underwood-Olivetti Corporation
American Tunaboat Association
Tuna Fishermen's Wives Emergency Committee
Scripps Institution of Oceanography, University of California at San Diego
Cannery Worker's and Fisherman's Union AFL-CIO (San Diego)
Seine and Line Union AFL-CIO (San Pedro)
Fishermen's Union, Local 33, ILWU
Fishermen's Cooperative Association (San Pedro)
Pan American World Airways
United States Navy
United States Army
United States Post Office (La Jolla and San Diego)
United States Bureau of Commercial Fisheries
Inter-American Tropical Tuna Commission
California Fish Canners Association
Kelly Girl Service, Inc.
California Department of Fish and Game
Wine Growers of California
Cafe del Rey Moro, Balboa Park
Van Camp Foundation
San Diego City Schools
City of San Diego
Garden Spot Market, San Diego

RESOLUTION 24

The Meeting,

Places on record its appreciation of the efficient and benevolent manner in which its Chairman, Mr. Brock, has conducted the proceedings.

IV SECTION AND WORKING GROUP REPORTS[1/]

REPORT OF SECTION 1/A

Species Identification
and Distribution: Adults

Chairman: B.B. Collette
Rapporteur: F.H. Talbot

1 References[2/]

MP/1A; EP/6, 7, 8, 18, 28, 32; SS/19

2 Discussion

The meeting decided to use Methodological Paper 1A as a basis for discussion to amend it in the light of this discussion, and to include the amended version as part of the record of the meeting as a tentative summary of present views of scombrid systematics. The amended paper which is appended hereto therefore is to be considered as part of this report.

3 Future Work

Although there is some broad agreement as to the classification of the scombrid fishes down to the generic level, much work remains to be done on the species and sub-species. This requires examination of large series of graded-sized specimens on a world-wide basis. Such collections are at present sorely lacking. In addition to classical meristic and morphometric taxonomic methods, there is great need for comparative anatomical work. This approach has proved its usefulness in the higher scombrids, particularly in the genus *Thunnus*.

4 Cooperation

International cooperation is vital to any study that will solve the taxonomic problems present in this family of wide-ranging species.

5 Suggested Resolutions

(1) The Meeting notes that the papers by Collette (1961)[3/] and Collette and Gibbs (Methodological Paper 1A) have filled the need for a preliminary review of tuna systematics expressed at the Symposium in Dakar and that the latter paper answers the specific request made by the Honolulu Conference.

(2) The Meeting notes that the species of the genus *Euthynnus* are still in need of revision as stated at the Symposium in Dakar.

(3) The Meeting notes also the recommendation of the Symposium at Mandapam Camp, for international effort for a review of scombrid fishes on a world-wide basis.

(4) The Meeting notes the need for work on large collections of scombrid fishes from all over the world to solve the systematic problems in these wide-ranging species and genera and further notes the difficulty and expense of both gathering and housing such collections.

(5) And the Meeting therefore recommends that a few major centers with adequate manpower, storage and library facilities be selected for the accumulation of the necessary specimens,

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1/ For information on Dakar and Mandapam Camp Symposia and Honolulu Conference see Appendix 1

2/ For full names of papers see pages 80-84.

3/ Collette, B.B., 1961 A preliminary review of the tunas of the genus *Thunnus*, unpubl. Paper No.VI-1, Pacific Tuna Biology Conference, Honolulu, Aug. 1961, 30 p. Abstract in: Spec.sci.Rep.U.S.Fish Wildl.Serv.Fish., (415):24

to make possible the examination of world-wide material by interested research workers.

(6) The Meeting recommends that among such selected centers there should be included the U.S. National Museum, Washington, and the Muséum Nat. d'Histoire Naturelle, Paris. These two centers are recommended because in addition to the prerequisites mentioned above, in the case of the U.S. National Museum there will be two systematists actively working on scombrid fishes, and in the second case a European area is geographically desirable, and the Muséum Nat. d'Histoire Naturelle has the most important existing collection of scombrid type material.

(7) The Meeting further notes that such selected centers would be of far greater value if adequate financial support were provided to facilitate the expensive task of shipping and housing such material.

(8) The Meeting requests aid in gathering this material on a world-wide basis from institutions and organizations interested in scombrids. Particular mention in this regard is made of the following:

U.S. Bureau of Commercial Fisheries
California Department of Fish and Game
Inter-American Tropical Tuna Commission
Philippine Bureau of Fisheries
Institut Français d'Océanie, Nouméa, Nouvelle Calédonie
Réseau Océanographie-Pêches Maritimes, ORSTOM, France
Division of Fisheries and Oceanography, CSIRO, Australia
Centre de Recherches Océanographiques, Abidjan, Côte d'Ivoire
Division d'Océanographie et des Pêches, Ministère de l'Economie Rurale et de la Coopération, Dakar, Sénégal
East African Marine Fisheries Research Organization, Zanzibar
Division of Sea Fisheries, South Africa
Federal Institute for Fisheries Research, Federal Republic of Germany
Nankai Regional Fisheries Research Laboratory, Japan
Directorate of Fisheries, Bergen, Norway
Instituto de Investigación de los Recursos Marinos del Perú
Instituto de Investigaciones Pesqueras, Spain
Junta de Investigações do Ultramar Portugal
Central Marine Fisheries Research Institute, Mandapam Camp, India

(9) The Meeting further notes that in addition to the collection of material at these centers, travel is essential both for workers wishing to visit such centers, and for workers at these centers needing to examine larger series of material at other critical areas.

(10) The Meeting therefore recommends that national and international sources provide the essential funds and cooperation to facilitate such travel.

Methodological Paper No. 1A

A PRELIMINARY REVIEW OF THE FISHES OF THE FAMILY SCOMBRIDAE

By
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1 INTRODUCTION

1.1 Importance of the taxonomy of the Scombridae

In addition to the usual evolutionary interest, the taxonomy of the Scombridae is especially important because of the vital role of the tunas and mackerels in world fisheries. A number of the species migrate long distances and thus come into the catches of different fisheries. It is therefore necessary to know more about the species and their populations to manage the fisheries rationally. The taxonomy of the family must be clearly established, so that excessive name-changing will not further complicate the accumulation of data on the various members of the family.

This paper was prepared in response to Resolution No. 1 of the Pacific Tuna Biology Conference held in Honolulu, Hawaii in August, 1961.

1.2 Problems of taxonomy in the Scombridae

Several factors have made the taxonomy of the Scombridae more difficult than that of many other families. The large size of many species, especially of some of the tunas, makes it difficult if not impossible, to store the large series necessary for thorough taxonomic work. Many observations, therefore, have to be made at the time of collection, often under adverse conditions and, as the specimens usually must be disposed of, there is no opportunity of checking the accuracy of these observations. Many species of Scombridae are wide-ranging, with some of the tunas having world-wide distributions. Thus workers have been virtually forced to confine their studies to only a portion of the range of a given species. This provincialism has led to the description of too many species in many of the genera. Many of the easily countable structures in the scombrids are very similar from species to species within a genus. Thus, morphometrics have been extensively used to separate species and sub-populations. Some of the scombrids reach large sizes which make changes due to growth difficult to evaluate. The search for characters has led, in the tunas, to the use of internal characters in the osteology, circulatory system, and position of the viscera. The use of the patterns of the circulatory system usually requires the use of fresh or frozen specimens, which makes the task of obtaining the adequate material still more difficult.

2 THE FAMILY SCOMBRIDAE

Regan (1909) defined the family Scombridae and distinguished it from related families such as the Gempylidae, Trichiuridae, Luvaridae, Istiophoridae, and Xiphiidae. Kishinouye (especially 1915 and 1923) divided the Scombridae into four families: Scombridae, Cybiidae, Katsuwonidae and Thunnidae, the last two of which he recognized as the order Plecostei, separate from all other higher bony fishes (which he called Teleostei). He based these decisions upon detailed anatomical work on the Japanese scombrids. Although he was an excellent anatomist, his taxonomic conclusions were poor, and Berg (1940, 1955) is the only present-day ichthyologist of note to separate the tunas (under the name Thunniformes). Takahasi (1926) early pointed out that the subcutaneous circulatory system of the "Plecostei" was not unique, as Kishinouye had claimed, and so invalidated his "order". Starks (1910), Fraser-Brunner (1950), and also the present authors' work indicates that the Scombridae is a natural family.

3 THE GENERA AND SPECIES OF SCOMBRIDAE

3.1 Introduction

The generic status of the members of this family has vacillated back and forth from the extremes of several very large genera to many monotypic or oligotypic genera. The genera that the present authors recognize will be discussed briefly below. These are the same as those recognized by Fraser-Brunner (1950), but we feel that our arrangement is a closer approach to a natural phylogenetic order. The species utilized here should be considered tentative in all genera except *Thunnus*.

3.2 *Gasterochisma* Richardson

This monotypic genus (*G. melampus* Richardson) has been placed in a separate sub-family, the Gasterochismatinae, by Fraser-Brunner (1950) because of its large cycloid scales, lack of caudal keels, and other characters. It is so

different from the Scombrinae that it may have to be placed in a separate family.

3.3 *Scomber* Linnaeus

3.3.1 Status of *Pneumatophorus* Jordan and Gilbert

The authors agree with Fraser-Brunner (1950) that *Pneumatophorus* is a synonym of *Scomber*. The presence of an air bladder sometimes varies even within a species in the Scombrinae, so this does not seem to be a valid generic character.

3.3.2 Position of *Scomber*

Scomber and *Rastrelliger* appear to be the most primitive genera of the subfamily Scombrinae. They are fully scaled, have a low number of vertebrae (31), have two small keels on the side of the caudal peduncle, and the dorsal fins are widely separated.

3.3.3 Species of *Scomber*

Fraser-Brunner (1950) recognized only two species; the cosmopolitan *S. japonicus* Houttuyn, which has an air-bladder, and the Atlantic-Mediterranean *S. scombrus* Linnaeus, which lacks an air-bladder. Manacop (1958) distinguished an additional species in the Philippine Islands, *S. australasicus* Cuvier, on the basis of greater body depth, larger scales, and a more compressed body. In these characters, *S. australasicus* is more closely related to *Rastrelliger* than either of the other two species of *Scomber*.

During the discussion C.L. Hubbs and J.E. Fitch (U.S.A.), and I.A. Ronquillo (Philippines), agreed that there are two species of *Scomber* in the Pacific. E. Postel (France) pointed out that *Scomber japonicus* shows striking geographical variations in body size down the African coast. Additional study is needed to explain this phenomenon.

3.4 *Rastrelliger* Jordan and Dickerson

This genus differs from *Scomber* primarily in having numerous greatly elongated, feather-like gill-rakers as well as having larger scales and a more compressed body. Fraser-Brunner (1950) recognized two species: *R. canagurta* (Cuvier) and *R. brachysoma* (Bleeker). Using the same characters -- number of gill rakers and body depth -- Manacop (1958) also distinguished two species of *Rastrelliger* in the Philippines but used a junior synonym, *chrysozonus* Rüppel, instead of *canagurta* Cuvier.

Ronquillo supported Manacop's (1958) statement during the discussion.

3.5 *Scomberomorus* Lacépède

3.5.1 Generic synonyms

Munro (1943) divided this genus into nine subgenera: *Scomberomorus* Lacépède, *Cybium* Jordan and Hubbs, *Sawara* Jordan and Hubbs, *Pseudosawara* Munro, *Indocybium* Munro, *Sierra* Fowler, *Chriomitra* Lockington, *Cybiosarda* Whitley, and *Lepidocybium* Gill. Later Munro (1949) removed *Lepidocybium flavobrunneum* (Smith) from the Scombridae and, on the basis of its caudal structure, placed it in the Gempylidae. Fraser-Brunner (1950) recognized only *Scomberomorus* and *Cybium* as subgenera. Mago-Leccia (1958) hypothesized that on osteological grounds *Scomberomorus* may be divisible into two subgenera.

3.5.2 Species of *Scomberomorus*

Munro (1943) recognized a total of 17 species in the genus and then (1949) made it 16 by subtracting *L. flavobrunneum*. Fraser-Brunner (1950) recognized only 9 species. Additional work is plainly needed to clarify this situation.

3.6 *Grammatorcynus* Gill

This monotypic Indo-Pacific genus [*G. bicarinatus* (Quoy and Gaimard)] is closely related to *Scomberomorus*. It differs primarily in having two lateral lines and fewer vertebrae.

3.7 *Acanthocybium* Gill

This is another monotypic subgenus [*A. solandri* (Cuvier)] that has been derived from *Scomberomorus*. It has completely lost its gill rakers, the vertebrae are increased to 54-66 (Conrad 1938), and its jaws are beak-like. Mago-Leccia (1958) also pointed out the relatively close relationships between *Acanthocybium* and *Scomberomorus*.

3.8 *Orcynopsis* Gill

This monotypic subgenus, together with the next one (*Gymnosarda*), forms a link between the more primitive and the more advanced members of the Scombrinae. Both genera have a moderately low number of vertebrae (38). *Orcynopsis unicolor* (Geoffrey St. Hilaire) is limited to the eastern Atlantic and Mediterranean.

Postel stated that these two genera were very closely related and might be considered congeneric.

3.9 *Gymnosarda* Gill

The sub-family Scombrinae can be divided into two subgroups at this point. *Scomber, Rastrelliger, Scomberomorus, Grammatorcynus,* and *Acanthocybium* have caudal notches and lack bony caudal keels. *Orcynopsis, Gymnosarda, Sarda, Auxis, Euthynnus, Allothunnus,* and *Thunnus* lack caudal notches and have bony caudal keels. *Gymnosarda* is characterized by the possession of large conical teeth that are curved forward. Fraser-Brunner (1950) recognized two species in this genus: *G. elegans* (Whitley) and *G. unicolor* (Rüppell).

3.10 *Sarda* Cuvier

3.10.1 Generic position

Sarda differs from the four more advanced genera in lacking a cutaneous circulatory system and in lacking prootic pits (Godsil 1954). There are more vertebrae (44-52) in *Sarda* than in any of the other members of the more advanced sub-group (36-41).

3.10.2 Species of *Sarda*

Godsil (1955) recognized two species complexes within *Sarda*: the *Sarda chiliensis* complex characterized by gill-teeth developed on the first gill-arch, 20-27 gill-rakers, and 20-25 teeth on each side of the lower jaw, and the *orientalis-velox*-complex characterized by a lack of gill-teeth, only 8-13 gill-rakers, and only 10-15 teeth on each side of the lower jaw.

Mather pointed out that the Atlantic and Pacific populations of *Sarda* must be considered distinct because of differences in vertebrae counts, *Sarda sarda* in the western Atlantic having about 52, and the eastern Pacific forms having about 44.

De Vildoso (1955, 1962) felt there were two distinct species in the eastern Pacific: *Sarda velox* and *Sarda chiliensis*. She further indicated the possibility that the disjunct populations of *Sarda chiliensis* might represent two sub-species: *Sarda chiliensis lineolata* on the coast of California and Mexico with an average of one more vertebra than *Sarda chiliensis chiliensis* along the coast of South America.

Klawe (as noted by Rivas, 1951) suggested that Breder's (1932) reference to the occurrence of *Sarda velox* in the Atlantic off Block Island might be in error.

If four nominal species be recognized, they would be: *Sarda sarda* in the Atlantic and Mediterranean, *Sarda velox* and *S. chiliensis* in the eastern Pacific, and *Sarda orientalis* from the western Pacific and Indian Ocean.

3.11 *Allothunnus* Serventy

This monotypic genus is the most recently described (Serventy 1948) in the Scombridae. *Allothunnus fallai* differs strikingly from all other scombrids in its great number of gill-rakers (71-75; Serventy 1948, and Talbot 1960). The other scombrids vary from 0 (in *Acanthocybium*) to 53-63 (in *Euthynnus pelamis*).

Talbot mentioned that a second specimen of *Allothunnus* had been taken in South Africa. The genus lacks a subcutaneous vascular system and the frontoparietal foramina, as found in *Euthynnus* and *Thunnus*. Furthermore, prootic pits are present but are not as marked as in *Auxis, Euthynnus,* or *Thunnus*. An anterior corselet is present, and scaling behind this is variable (Talbot in press).

3.12 *Auxis* Cuvier

3.12.1 Generic position

Auxis is the most primitive of the higher tunas to have developed a prootic pit and a partial subcutaneous circulatory system. It differs from the two more advanced genera (*Euthynnus* and *Thunnus*) by lacking the prominent frontoparietal foramina present in the crania of that group. It is similar to *Euthynnus* in having a naked body behind the well-developed corselet.

There are 39 vertebrae in *Auxis*, as in *Thunnus*. The two dorsal fins are widely separated in *Auxis*, as in the much more primitive genera *Scomber* and *Rastrelliger*.

3.12.2 Species of *Auxis*

Fraser-Brunner (1950) recognized only a single world-wide species, *A. thazard* (Lacépède). At about the same time, Wade (1949) distinguished an additional species, a long-corseleted Pacific form, *A. tapeinosoma* Bleeker. Matsumoto (1960) has recently resurrected the name *A. thynnoides* Bleeker to apply to the long-corseleted form of the western Pacific. He placed the names *A. hira* and *A. maru* Kishinouye, together with *tapeinosoma* Bleeker, as synonyms of the short-corseleted, world-wide *A. thazard*. Fitch and Roedel (1962) tentatively recognize two world-wide species, *A. rochei* Risso and *A. thazard*, on the basis of dorsal pattern, width of corselet under the second dorsal, position of the anterior end of the dorsal bare area with respect to the pectoral tip, several skeletal features, and, possibly, pored lateral-line scale counts. Fitch pointed out a habitat difference between these two species, *A. rochei* being found close to land and *A. thazard* being found typically off shore, at least in the eastern Pacific.

3.13 *Euthynnus* Jordan and Gilbert

3.13.1 Generic position

A number of recent authors have recognized two genera: the monotypic *Katsuwonus* Kishinouye for the skipjack (*E. pelamis*), and *Euthynnus* for the little tunas (Godsil and Byers 1944; Fraser-Brunner 1949; Rivas 1951; Godsil 1954). In other papers (e.g., Fraser-Brunner 1950) *Katsuwonus* has been considered as a subgenus of *Euthynnus*. Their close relationship has been emphasized by Kishinouye (1923), Godsil (1954), and others who have followed Kishinouye's classification, where *Katsuwonus* and *Euthynnus* are placed in the "Katsuwonidae" together with *Auxis*. Externally, *E. pelamis* differs from other species of *Euthynnus* by the lack of black markings above the lateral line and the presence of longitudinal, oblique, black stripes on the silvery belly. Internally, *E. pelamis* is more advanced than other members of *Euthynnus* in having the dorsal and ventral branches of the cutaneous artery about equally developed. In *Euthynnus* proper, the ventral branch is short and dendritic (Godsil 1954). There are slightly more vertebrae in *E. pelamis* (41) than in the other species of *Euthynnus* (36-39); however, in spite of the differences that exist between *Katsuwonus* and *Euthynnus*, the present authors think it more indicative of relationships to unite the two into a single genus, as done by Fraser-Brunner (1950). This choice is based largely on the separation of *Euthynnus* from *Auxis* on the one hand (fronto-parietal foramina absent in *Auxis*) and *Thunnus* on the other (well-developed subcutaneous circulatory system and first vertebra ankylosed to skull in *Thunnus*).

3.13.2 Species of *Euthynnus*

Fraser-Brunner (1949, 1950) recognized two species, *E. affinis* (Cantor) and *E. alletteratus* (Rafinesque) in addition to the skipjack *E. pelamis* (Linnaeus). Fraser-Brunner (1949) divided *E. affinis* into three subspecies: *E. affinis affinis* (Cantor) from the Red Sea, Indian Ocean, Australia, Thailand, and Formosa; *E. a. yaito* Kishinouye from Japan, Hawaii, and Pacific islands; and *E. a. lineatus* Kishinouye from the Pacific Ocean off Central America. Present evidence indicates that *E. lineatus* may be a valid species while *E. yaito* may best be considered as a synonym of *E. affinis*. Fraser-Brunner (1949) described a new subspecies *E. alletteratus aurolitoralis* from Ghana. This appears to be a color variant within the range of variations in *E. alletteratus* and should be synonymized with it.

3.14 *Thunnus* South

3.14.1 Introduction

There is at least one generic name available for all but one of the six species of *Thunnus* that are recognized by the present authors: *Thunnus* for the bluefin tuna, *T. thynnus*; *Germo* Jordan for the albacore, *T. alalunga*; *Neothunnus* Kishinouye for the yellowfin, *T. albacares*; *Parathunnus* Kishinouye for the bigeye, *T. obesus*, and blackfin, *T. atlanticus*; and *Kishinoella* Jordan and Hubbs for the longtail, *T. tonggol*. Except for Jordan and Evermann (1926), most reviews of the great tunas have placed *Germo* in the synonymy of *Thunnus*. However, the majority of recent workers have recognized

Thunnus, *Neothunnus*, *Parathunnus*, and *Kishinoella*, either as genera (Godsil and Byers, 1944; Godsil, 1954) or sub-genera (Fraser-Brunner, 1950; Rivas, 1961). However, the present authors feel that the differences between all of these "genera" are specific and not generic differences (Gibbs and Collette, MS) and thus follow such authors as Rivas (1951) and de Sylva (1955).

3.14.2 Species of *Thunnus*

3.14.2.1 The bluefin tuna, *Thunnus thynnus* (Linnaeus)

Different authors recognize varying numbers of species or sub-species in what we believe to be one world-wide species. Ginsburg (1953) has presented the most extreme viewpoint in the recent literature, recognizing an eastern Atlantic bluefin, *T. thynnus;* a western Atlantic *T. secundodorsalis* (Storer); and an eastern Pacific *T. saliens* Jordan and Evermann. He did not discuss the Japanese population, for which the name *T. orientalis* (Temminck and Schlegel) is available, or the Australian population, *T. maccoyii* (Castelnau). These were all considered as synonyms of *T. thynnus* by Fraser-Brunner (except that he placed *T. maccoyii* in the synonymy of *T. obesus*, a mistake rectified by Godsil and Holmberg, 1950). On the basis of anatomical characters (bulge in roof of body cavity, shape of air-bladder, gill-rakers, etc.), Godsil and Holmberg (1950) recognized the Australian *T. maccoyii* as a species separate from an Atlantic-California coast *T. thynnus*. Serventy (1956a) has expressed the view that there are six isolated populations within the single world-wide species *T. thynnus*. On the basis of number of gill-rakers and other characters, we feel that there is justification for separating an Atlantic subspecies (*T. thynnus thynnus*) from an Indo-Pacific subspecies (*T. thynnus orientalis*), but that further sub-divisions should not be recognized by formal nomenclature. In this respect the present authors agree with Jones and Silas (1960). Talbot and Penrith (1962a, b) state that large populations of *Thunnus thynnus orientalis* occur west of Cape Town in the southern winter, while a few large specimens of *Thunnus thynnus thynnus* are taken in the same area in the summer months.

3.14.2.2 The bigeye tuna, *Thunnus obesus* (Lowe)

Current opinion is divided as to whether the Atlantic form (*obesus*) is different from the Indo-Pacific form (*sibi* Schlegel 1844, or *mebachi* Kishinouye 1923). Fraser-Brunner (1950) synonymized *sibi* and *mebachi* under *obesus*. He also erroneously put *T. maccoyii* Castelnau, *T. phillipsi* Jordan and Evermann, and *Parathunnus rosengarteni* Fowler in the synonymy of *T. obesus* (corrected by Rivas, 1961). Jones and Silas (1960) recognized the Indo-Pacific form as *Parathunnus obesus mebachi*. (The name *sibi* has priority over *mebachi*, so their subspecific name is incorrect if the forms were different). Rivas (1961) considered *obesus* and *sibi* as valid species, distinguishing them on the basis of pectoral fin length. We find this character to be very variable and consider the Indo-Pacific and Atlantic forms to be conspecific. Frade (1960) has recently reviewed the literature on the eastern Atlantic population of *T. obesus*. Talbot and Penrith (1926a, b) have shown a continuous distribution of this species around the tip of Africa in summer.

3.14.2.3 The yellowfin tuna, *Thunnus albacares* (Bonnaterre)

Due mainly to proportional differences, there is more confusion about this species than others in the genus. Jordan and Evermann (1926) recognized six species: *Neothunnus catalinae* Jordan and Evermann from southern California; *N. macropterus* (Schlegel) from Japan to Hawaii; *N. albacora* (Lowe) from Madeira; *N. itosibi* Jordan and Evermann from Hawaii and Japan; *N. albacores* [sic] (Bonnaterre) from Madeira and the West Indies; and *N. allisoni* (Mowbray) from Florida. The main differences between these forms are in the relative lengths of the second dorsal and anal fins. Fraser-Brunner (1950) placed all these names in the synonymy of *T. albacora* (Lowe), although the name *albacares* (Bonnaterre) clearly has priority. Most workers have not completely agreed with him, usually recognizing an Indo-Pacific species (*macropterus*) distinct from the Atlantic (*albacares*).

For example, Ginsburg (1953) recognized four species based on the relative lengths of the second dorsal and anal fins: *T. albacares* from the eastern Atlantic; *T. subulatus* (Poey) from the western Atlantic; *T. catalinae* from the eastern Pacific; and *T. macropterus* from the central and western Pacific. Rivas (1961) has indicated and Royce (1961) has shown conclusively that there is only a single pantropical species with a continuous distribution. Talbot and Penrith (1962a, b) have shown a continuous distribution of this species around the tip of Africa in summer.

3.14.2.4 The albacore, *Thunnus alalunga* (Bonnaterre)

Jordan and Evermann (1926) recognized the Pacific albacore as a distinct species (*germo* Lacépède) from the Atlantic albacore (*alalunga*). Most recent workers have concluded that the albacore is a single world-wide species (Fraser-Brunner, 1950; Rivas, 1951; etc.) and the studies of the present authors confirm this. Talbot and Penrith (1962a, b) report that this species is common west of Cape Town throughout the year.

3.14.2.5 The blackfin tuna, *Thunnus atlanticus* (Lesson)

This small Atlantic tuna has been confused with both the albacore, *T. alalunga*, and the bigeye, *T. obesus* Fraser-Brunner (1950). Beebe and Tee-Van (1936) were the first to reaffirm clearly its distinctness, although this was apparently overlooked by Fraser-Brunner. This was further confirmed by Rivas (1951, 1961) and Bullis and Mather (1956) on the basis of the moderately long pectoral fin, low number of gill-rakers (20-24), and color of the finlets, etc., and by de Sylva (1955), who studied the osteology and relationships of *T. atlanticus*. Our studies further confirm its specific distinctness.

3.14.2.6 The longtail tuna, *Thunnus tonggol* (Bleeker)

This Indo-Pacific species of tuna is the least known member of the genus. Jordan and Evermann recognized three species: *Neothunnus tonggol* from Java; *Kishinoella rara* (Kishinouye) from Japan and *K. zacalles* Jordan and Evermann from Hawaii. The present authors (MS), found that *K. zacalles* has too many gill-rakers to be identified as *T. tonggol* and best fits the description of *T. albacares*. The longtail tuna (and the nominal "genus" *Kishinoella*) are characterized by the absence of a swim bladder, a low number of gill-rakers, and differences in body proportions. Serventy (1942) presented an account of the anatomy of this species and synonymized *T. rarus* and *T. nicholsoni* Whitley with it. Fraser-Brunner (1950) followed Serventy (1942). Serventy (1956b) presented further information on the Australian populations of *T. tonggol*, and Jones and Silas (1960) recorded it from various localities in the Indian Ocean.

4 CONCLUSIONS

Although the general outline is fairly clear, there are a number of problems in the present classification of the Scombridae. Extensive international cooperation is needed to obtain the specimens to solve the existing taxonomic problems. The present authors are now completing a manuscript that will clarify the species and generic status of the genus *Thunnus*. Royce (1961) has completed a morphometric study of the yellowfin tuna, *Thunnus albacares*. Fitch and Roedel (1962) have presented a review of the frigate mackerels, genus *Auxis*. We hope that other workers will be interested in clarifying other problem areas within the family such as (1) the number of species of *Scomberomorus*; (2) the number of species and/or subspecies of mackerels, *Scomber*; (3) the number of valid forms of bonitos, *Sarda*; and (4) the family-subfamily-tribal level of classification of the group.

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REPORT OF SECTION 1/B

Species Identification
and Distribution: Larvae and Eggs

Chairman: S. Ueyanagi
Rapporteur: E. Ahlstrom

1 References

MP/1B; EP/5; SS/1, 2, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 20, 21

2 Discussion

Knowledge of the distribution, abundance, and biology of the younger stages in the life history of tunas can aid in the understanding of many problems in tuna population dynamics, including success or failure of year classes, population structure, sub-populations, and differential distribution and availability with age.

Basic to these studies is the knowledge of the eggs and larvae of each species. The eggs of most species of tunas are unknown. Currently, it is not possible to identify most scombroid eggs taken in plankton hauls by species. A prime reason for this is their similarity in size and appearance. Hence it is important that embryonic development of the various tunas be studied utilizing artificially fertilized eggs, to determine more exactly characters useful in specific identification of the eggs of each species. Such studies can also trace the changes in pigmentation that occur between the embryonic and larval stages, and establish the pattern of pigmentation present on early postlarvae of each species.

The identification of tuna larvae to genus can be accomplished with fair certainty, especially when dealing with larvae about four to five mm in length. Thus, larvae of *Euthynnus* can be separated from *Auxis*, *Sarda*, or *Thunnus*. The specific identifications of larvae of *Auxis*, *Sarda*, and *Euthynnus* are less certain, although at least two kinds of larvae are known for each genus. Identifications, some tentative, have been made of the larvae of five of the six large tuna comprising the genus *Thunnus* (cf. Methodological Paper 1/A), with problems remaining to be resolved as to identity of albacore larvae. Smaller larvae of tuna still are difficult or impossible to identify with certainty to species, hence a prime need is the detailed analysis of developmental series of each species. These studies should utilize all available tools - morphometrics, meristics (including teeth and gill-raker development), sequence of pigment changes, rate of differentiation of structures as related to size, and larval characters (preopercular spines, supraorbital ridge, etc.).

Identification of juveniles can be accomplished by use of adult characters, such as fin-ray counts, skeletal structures (determined by X-ray or on cleared and stained specimens), visceral arrangement, color patterns. Actually, difficulty in juvenile identification depends on the size of specimens being examined. The juvenile stage begins at about 15 mm in length (at completion of fin formation) and extends to a poorly defined point, adolescence. For practical purposes, juveniles can be considered to comprise 0 age fish older than larvae. There is less of a problem in identifying juveniles than in capturing them. Methods available for capture include stomach contents of fish and sea snakes, dip netting under lights from research or fishing vessels, and capture by net or trawl. Improved methods of capture of juveniles are needed, especially methods which will enable quantitative sampling.

Investigation of early stages of tunas is of importance in various aspects of the population dynamics and biology of tunas. Perhaps the most critical need in fishery biology is an understanding of fluctuations in abundance of marine fish populations, particularly the success or failure of year classes. The early stages in the life cycle, embryonic and larval, are usually considered to be the critical stages with respect to mortality, the stages during which the success or failure of year broods is largely determined. Survival is mediated through the oceanic environment -- physical, chemical, and biological -- hence the importance of understanding the effects of environmental factors on survival of young.

Investigation of effects of environmental variables on survival of organisms can be accomplished most effectively in the laboratory, where factors can be controlled. This presently is not

possible with pelagic marine fish larvae, because of the difficulty of rearing them in the laboratory. The problem of rearing pelagic larvae is such a critical one, and so much experimentation depends upon its successful solution, that a concerted effort is needed to accomplish this. Physiological investigations are being made on the early developmental stages (embryonic, yolk sac, and early stage larvae) of pelagic fishes such as Pacific sardine and Atlantic herring in order to understand such processes as osmoregulation, development in relation to temperature, efficiency of utilization of yolk, etc.

Information on growth during the larval and juvenile stages would not only be of value in survival studies but in such practical problems as establishing the size at which the first annulus is laid down, a controversial point in some tunas (for example, albacore).

In tuna research, investigation of larvae survival lies in the future. It requires systematic coverage of more extensive areas of the ocean than has been possible. It will also require extensive laboratory research on rearing of young and, when this has succeeded, controlled experiments on the effects of environmental variables on their survival.

Detailed descriptions of the development and morphology of young stages of tuna can contribute to the classification of tunas. When there is a question about whether two species are identical or not, as for example *Sarda chiliensis* and *Sarda sarda*, maybe the eggs and larvae of these forms will aid in establishing their identity or separateness.

Studies of eggs and larvae can contribute to systematics by showing relationships between species. As an example, a close relationship of *Katsuwonus* to *Euthynnus* is indicated by the presence of chromatophores over the forebrain in larvae four to eight mm. Such chromatophores are lacking in *Auxis* and *Thunnus*.

Delimitation and definition of spawning areas on the basis of occurrence of eggs and larvae can make an important contribution to the solution of the subpopulation problem where a subpopulation is genetically a distinct stock of fish. Maintenance of its identity requires spatial or temporal isolation from other subpopulations at time of reproduction. An example of temporal separation of subpopulations is afforded by the spring spawning and fall spawning groups of Atlantic herring. An example of spatial separation is afforded by the Gulf of California subpopulation of Pacific sardine, one of three genetic subpopulations that have been identified by means of blood antigens.

Genetic differences in subpopulations may be reflected in larval characters, such as pigmentation. As an example, differences in the orange pigment pattern were observed on living yellowfin and albacore (tentatively identified) larvae from the Pacific and Indian Oceans, and these may prove to be genetic differences related to subpopulations.

The early stages in life history of some tunas appear to have different physiological requirements than adults. For temperate tunas, this may tend to restrict the spawning area to a portion of the range of the species. Albacore in the North Pacific appear to spawn in subtropical waters of the central North Pacific at about 15° to 25° N. Adults range over much of the North Pacific between 10° to 50° N. Bluefin larvae are known only from south of Japan in waters where the Kuroshio Current originates. Bluefin taken by fishermen in the eastern Pacific never show advanced stages of maturation of gonads. Although less is known of the distribution of bluefin in the North Pacific than of other tunas, the species may prove to be as wide-ranging as the albacore, and to have a localized spawning distribution.

Tunas of the genus *Thunnus* and the skipjack are wide-ranging pelagic species. Little tunas, bonito, and frigate mackerel spend their lives close to land masses, and their larvae have correspondingly coastal distributions, with only frigate mackerel occurring in offshore waters. Off Ghana and the Ivory Coast, for example, *Euthynnus* larvae are taken within 10 to 15 miles of the coast, yellowfin and skipjack between 10 and 100 miles from the coast, while *Auxis*, the most abundant of the scombroid larvae, occurs in greatest numbers along the coast, but also extends offshore.

3 Cooperation

There are many areas in which cooperation is needed between organizations conducting research on the younger stages of tuna; two problems of immediate concern are collecting methods and cooperative survey cruises.

Tuna larvae are sparsely distributed, and because of this, it is necessary to strain rather large quantities of water when making quantitative collections. Tuna larvae are confined in their vertical distribution to the upper mixed layer and the upper portion of the thermocline, consequently their complete depth distribution can be encompassed in most areas by hauls extending to 140 meters deep, in all areas by hauls extending 200 meters deep. The type of plankton haul that effectively encompasses the vertical range and yet strains adequate quantities of water (500 to 1000 m^3) is an oblique tow taken with a net 1.0 meter in diameter at the mouth and approximately five meters in overall length. This net has become the standard gear in the tuna programs of the eastern and central North Pacific.

There are so many additional problems involved in the quantitative sampling of fish eggs and larvae of tuna -- mesh size needed for full retention of eggs and larvae, the daytime escapement of larger larvae, the non-random areal distribution of eggs and larvae, the varying capabilities of research vessels, etc. -- that the task of establishing criteria for taking comparable hauls will require considerable consultation between organizations conducting tuna research.

Cooperative survey cruises in the Pacific have already been initiated with NORPAC and EQUAPAC, and a pattern of cooperation established that should be further developed. NORPAC (1955) achieved a semisynoptic coverage during the summer season of the North Pacific above 20° N. Similar coverages are needed at other seasons both to establish the seasonal occurrences and distributions of pelagic fish eggs and larvae, including temperate tunas (albacore and bluefin), and to chart the seasonal distributions of physical, chemical, and biological properties such as temperature, current patterns, essential nutrients (phosphates, nitrates), and productivity. Cooperative cruises in both the North Atlantic and North Pacific have been proposed by the U.S.S.R. The wide belt of the tropical Pacific, between 20° N and 20° S has yet to be covered over its whole extent. Semisynoptic coverages of this important tuna area by season would provide invaluable information on the distribution of tuna larvae and other fish larvae, on the distribution of physical properties, on productivity, and on zoogeography.

The present emphasis on the oceanography of the Indian Ocean affords opportunities for the collection of extensive materials. It may well be possible to establish the distribution and abundance of tuna and other fish larvae in the Indian Ocean, if these opportunities are not neglected.

REPORT OF SECTION 2

Population Identification

Chairman: J.C. Marr
Rapporteur: P.M. Roedel

1 References

MP/2; EP/3, EP/22

2 Discussion

2.1 General

Populations were defined as the biological units by which tuna reproduce, grow and die -- the natural units which we must be able to identify and whose ranges we need to determine. It was evident that all concerned regarded this field as one of especial importance to tuna research. The term "population" was used interchangeably with "subpopulation", which led to recognition of the need for a definition of terms.

The discussion brought out the danger inherent to thinking of subpopulations as existing in a steady state in geographically fixed and distinct areas, as has been done traditionally. It is becoming clear that in considering the geography of subpopulations one must employ a moving, not a fixed, point of reference, likely associated with water masses or types, the location of which varies. Two subpopulations may occupy the same

geographic area at different times, or at the same time if this does not coincide with spawning. The question of how much mixing may take place before two subpopulations are no longer "independent" received considerable attention at the Honolulu Conference, and the importance of resolving the problem was emphasized in Resolution 9 of that conference.

Throughout the discussion the need was emphasized for full knowledge of habitat before one can with surety interpret the results of subpopulation studies. The thought was expressed that tuna scientists stand on the brink of a new understanding, that in the sea nothing is fixed save geography and the bottom. From a practical standpoint, this means one may be able to predict the kind and size and time of appearance of fish by monitoring physical, chemical and biological conditions in the ocean. The question was raised as to the nature of the isolating mechanisms in water masses. What is it that confines a subpopulation to a water mass?

It was noted that data collected routinely for other purposes might be of considerable value in delineating populations.

Discussions of "mixing" in relationship to morphometric studies emphasized the need for general definition of terms. It was pointed out that "mixing" in the various concepts employed might refer to mixing in the catch, mixing in the processing plants, or mixing of gametes -- random mating.

2.2 Methodology

Solutions to population problems have generally been sought through three avenues: morphometrics, tagging and blood groups. In addition, various workers have and are investigating other characteristics, such as serum proteins, muscle amino-acids, eye lens proteins, sperm morphology, base composition of testis DNA, and parasite faunas.

The concensus was that the methodology of tagging and blood group studies was in a reasonably advanced state, though improvements could always be made, but that morphometric studies left much to be desired.

2.3 Morphometrics

Despite the significant advances which have been made in handling and interpreting such data, the results of studies have been equivocal, because of the question as to whether the differences measured were environmentally or genetically produced. The zeal with which new methods have been sought attests to this deficiency. While the general opinion was that the method did not hold great promise, it was pointed out that this tool should not be discarded because of its limitations, that it still has possibilities, the mathematical difficulties have been overcome, and it may in some instances be the only tool available.

The question of the meaning of mixing and the rate of mixing as shown by overlap in the newer and more sophisticated analyses was raised, but not resolved, except to point out that interpretation depended upon the type of sampling. It might represent two subpopulations passing through the same area at different times or it might represent actual mingling of two subpopulations. For understanding and management we need to know which situation prevails in each instance.

2.4 Tagging

Tuna tagging on a large scale became possible a decade ago with the development of the "spaghetti" tag and the subsequent development of the dart tag.

The most spectacular results have stemmed from relatively small-scale operations which have demonstrated the transoceanic movements of north Pacific albacore and north Atlantic bluefin. Large-scale operations, such as the yellowfin and skipjack programs in the eastern tropical Pacific, have contributed greatly to the sum of knowledge. In these cases such operations demonstrated within area migrations, as opposed to transoceanic migrations, except for one skipjack which moved from the American mainland to Hawaii. From the yellowfin studies, one can infer that two population components exist in the area of this fishery, but whether these are genetically distinct populations is an open question.

The use of radioisotopes as tags was considered briefly, but was judged impractical and undesirable on several grounds.

The use of age groups and length frequencies to aid in delineating stocks and in following migratory patterns was noted for several tunas, such as bluefin in the eastern Atlantic and albacore in the north Pacific, and yellowfin in the eastern Pacific.

A number of participants voiced the need for new or expanded tagging programs on various tunas in various parts of the world. Reference was made to the resolutions adopted at the Honolulu conference with respect to Pacific albacore and Australian bluefin. For the latter, a program is under way; the suggestion was made that an intensive and geographically expanded program would be most desirable in that region. An eastern north Pacific bluefin tagging program is projected for this year.

2.5 Blood Groups

Through studies of blood groups with standard immunological techniques, it is possible to determine whether several samples represent a single subpopulation, and whether a single sample represents one subpopulation or a mixture. Blood groups are under genetic control and it was noted that geneticists believe subpopulation differences must have developed over periods of centuries rather than decades.

Difficulties in the use of this technique concern collection and transportation of samples. The discussion brought out that there is much variability in this regard among species. For example, skipjack must be bled within two or three hours of death, whereas yellowfin and bigeye can be bled after several days, provided they have been iced, not frozen. These latter similarly withstand shipment better than skipjack. The status of bluefin has not yet been checked. Blood samples have been successfully shipped by air between such distant places as Capetown and Honolulu.

One example, elsewhere unreported, of the usefulness of blood group data, was noted. Earlier work on skipjack in Hawaiian waters utilizing length frequencies showed anomalies between winter and summer fish which could not be explained. Serological studies suggest that two populations, associated with two distinct water masses, may exist. In this light, the frequencies become intelligible.

While results of experiments so far have been most gratifying, there obviously remains far more to do than has been done. The need for world-wide co-ordination recurred in comments, as did the need for standardized terminology. Both of these topics were subjects of resolutions at the Honolulu Conference, which called for establishment of a center in Honolulu to aid in the exchange of blood samples and reagents, and in standardizing terminology. A modest start has been made in implementing these resolutions.

2.6 Parasites

The need for caution was emphasized unless the life history of the parasite in question is known. It is also possible that a given subpopulation might be exposed to a certain parasite only in certain portions of its range and that minor differences in migrations could expose only a portion of that subpopulation to infestation. It was suggested that the gills were a likely site to examine for parasites, since those on the body were too easily lost. Such parasites on North Sea and Mediterranean bluefin proved to be the same, as expected, showing the usefulness of such an approach. Also, Atlantic yellowfin have been found to have a specific trematode parasite.

2.7 Other Methods

There was little comment save to note that work is being carried out in the fields of serum proteins and sperm morphology, among others, and that the results are expected to be published in the near future. A pre-print of a paper describing preliminary experiments with eye lens proteins was distributed.

3 Future Work

The discussion pointed up:

(1) The continuing need to improve existing methods and actively to seek out new techniques,

(2) The importance of greatly

expanding work in this area with especial attention to the relationships of subpopulations to water masses and current systems,

(3) The need for additional information regarding Pacific tunas, despite the amount of work already carried out, and the pressing nature of this need,

(4) The need for definition of terms in general use,

(5) The importance of establishing a central facility for the exchange of blood samples and reagents, and for the standardization of nomenclature for blood group systems,

(6) The need for initiating or expanding tagging programs in many regions, e.g. bluefin in the north Atlantic and Mediterranean, the north Pacific and in the Australian region, and small albacore in the Pacific.

4 Cooperation

To fully implement existing studies and to fulfil expressed needs obviously calls for cooperation among all nations concerned with the tuna resources. Successful tagging programs generally require the efforts of several nations to insure return of tags, if not to apply them. Blood genetic studies would be greatly facilitated if the needs expressed in the preceding section could be implemented. In fact, all the items mentioned therein are not only amenable to joint effort, but also need joint effort if maximum results are to be attained from facilities available to the tuna scientist. Specifically, attention might be given to the establishment of a blood center and to the standardization of terms, both in general and with specific respect to blood groups. The meeting might also wish to consider the desirability of a special conference devoted to the problems of serology alone.

5 Suggested Resolutions

(1) The Meeting should support resolution 2 of the Honolulu Conference, as contained in Information Paper no. 3,[1/] with respect to a center for blood samples and reagents, modified as seems appropriate in the light of findings of the Working Group which it is anticipated will be assigned to consider this problem during the Meeting. It should urge implementation of recommendation 8 of that conference with respect to improved methods for the transport and storage of blood samples, and the utilization of wide-ranging tuna fleets to collect such samples.

(2) The Meeting should consider recommendations made by the Working Group 3, Stock Transfers.

(3) The Meeting should urge all nations concerned to attack the many problems raised with all possible vigor, using not only the established means of tagging and serology, but seeking out new approaches and drawing on techniques developed in other disciplines which may be fruitful.

(4) The Meeting should encourage such programs as:

(a) Tagging southern bluefin in the Australian region, tagging small albacore (less than 50 cm) wherever they may be found in the north Pacific and tagging albacore in the southeast Pacific, essentially as proposed at the Honolulu Conference in resolutions 4A, B and C.

(b) Augmented studies of blood group systems in yellowfin, skipjack, albacore and other species throughout the Pacific.

1/ Appendix I of this report.

REPORT OF SECTION 3

Size and Composition of Tuna Stocks

Chairman: J. Hamre
Rapporteur: G.L. Kesteven

1 References

MP/3; EP/5, 15, 20, 24;
All Species Synopses

2 Discussion

The meeting considered stock composition with respect to age and size, and in connection with these characteristics discussed

(a) methods of age determination,

(b) methods of calculating growth,

(c) reproduction and recruitment,

(d) methods of estimating mortality,

The discussions were based on the account of these matters presented in Methodological Paper 3. The following Table summarizes the data presented in Species Synopses relative to the matters under discussion in this session.

2.1 Stock Identity

A matter of fundamental importance to inquiries concerning the structure and size of stocks is the correct identification and delimitation of the stocks themselves. This matter is discussed elsewhere in the Meeting and consequently it will suffice to say at this point that work on structure and dynamics is likely to remain somewhat tentative as long as doubt surrounds the identification of any stock. On the other hand, the work on structure and dynamics itself provides evidence on the degree of autonomy of a stock. This follows from the definition of unit stock.

2.2 Stock Structure

The structural features of a stock derive from the numerical representation of categories defined with respect to size, age, sex and sexual condition. These categories constitute a multi-dimensional frame, each compartment of which possesses certain reproductive and growth potentials and certain expectancies of death and of survival. A study of a stock involves a two-fold task: on one side of determining the intrinsic potentialities and expectancies of each compartment (or group of compartments), and on the other of ascertaining the numerical strength within each compartment and estimating population values for the potentialities and expectancies. In the Species Synopsis the first task is represented by Chapter 3, while the second task is represented by Chapter 4.

2.3 Size

There was no indication during the discussion of any problem concerning methods of measuring although steps toward standardization of measuring techniques and of methods of presenting measurement data may perhaps become necessary. Size is sometimes reported as length and in other cases as weight; both would seem acceptable but if only one is given a length/weight key, or equation should be provided. Length/weight equations are given for several species; the Meeting recommends that the equations be prepared for other species.

Attention was drawn to the possible significance with regard to migrations and nutritional history of differences in "condition". No "condition" studies have been reported.

Examination of the following table will show that extensive deficiencies exist in our knowledge of the size characteristics of tuna stocks. The commonest measure given is greatest observed length and/or greatest observed weight. More informative measures are $L\infty$ and $W\infty$, but these can be calculated only if age determination is possible, and if a growth curve can be calculated; growth curves (or the data for these) are presented in several synopses but growth equations are not presented with the exception of one for *T. obesus* in Experience Paper No. 24; the Meeting recommends that these equations be calculated as soon as possible.

Other size characteristics of stocks, of significance in studies of stock size and dynamics, are length and weight at first maturity, and length and weight at recruitment. These have been given for a few species, but generally only most tentatively. Since determination of these characteristics is not dependent upon the availability of age-determination techniques and can be accomplished through measuring programs appropriately

designed with regard to sampling requirements, the Meeting recommends that work on these characteristics be undertaken at the earliest opportunity.

2.4 Age

Age determination by Petersen's method and by reading scales, vertebrae and other hard structures has been attempted with most species, with varying success. Much confidence is placed in age determinations made for the Atlantic bluefin, using vertebrae and scales. Confirmatory evidence has been obtained in some cases from tagged fish; the Meeting was informed of an experiment in the use of tetra-cycline product injected into fish at the time of tagging release, with a view to marking hard structures. The use of these supplementary methods of testing and refining techniques of interpreting length frequency curves and features of hard structures can be recommended.

The Meeting recommends that steps be taken to set up arrangements, in connection with age determination, for

(1) collaboration in developing and standardizing techniques of reading and interpreting scales and other hard structures;

(2) collaboration in the conduct of experiments in the supplementary techniques;

(3) exchange of results from the use of these several techniques.

2.5 Sex and Sexual Condition

Data on sex ratio are presented for many of the species. In some cases there are strong variations, between times and between localities, in sex ratio. Such differences could be of genetic origin, that is, could reflect true differences of abundance between the sexes, but also they could reflect differences of accessibility or of vulnerability between the sexes; alternatively, they could depend on differential in rate of growth or rate of natural mortality between sexes, or they could also be merely sampling effects. If the observed differences are due to causes other than sampling they may mean differential incidence of fishing mortality, and since this could have considerable effect on any yield equations prepared, the Meeting recommends that further evidence on this question should be sought and carefully analyzed.

Information on reproduction is presented in several of the synopses, and Experience Paper No. 5 presents an account of reproduction in *Sarda chiliensis*. Tentative estimates of fecundity are given for several species although fecundity equation is given for only two species. Gonad maturation tables, gonad indexes, and fecundity equations should be prepared for all species, and steps should be taken to ensure standardization of these methods.

2.6 Population Sampling

Experience Paper No. 20 reports a method of sampling the Pacific albacore, in which use is made of two-stage sampling.

The primary objective of this work is the preparation, for each unit stock, of detailed tabulations of stock composition and characteristics, in the sense discussed in the preceding paragraphs. Species Synopsis No. 16 (for *Thunnus (Neothunnus) albacares*) presents information on stock characteristics, and Experience Paper No. 15 presents detailed information on the structure of the albacore stock in North Pacific areas. Other than these two documents, the Meeting had little information before it on the composition of stocks of the several species. Obviously there must be substantial development of research and monitoring programs to assemble data from which stock assessments can be made. While arrangements for the collection and publication of catch and effort statistics are discussed in another section of the Meeting, consideration must be given here to development of detailed arrangements for the compilation and publication of stock composition tables from year to year. The Meeting recommends that steps be taken at once to establish some permanent machinery to guide and assist such work.

2.7 Stock Size (Abundance) and Dynamics

The use of catch-per-unit-effort figures as index of stock abundance is becoming standard practice, and some of the Species Synopses, as well as

Experience Paper No. 15, present data of this kind. However, population researchers are well aware that data of this kind must be obtained, for each stock, over the full range of conditions prevailing in the stock area, and must be weighted in various ways relating to characteristics of fishing units, fishing gear and methods, and to stock density itself. The Meeting, therefore, recommends that steps be taken to ensure effective collaboration in the compilation and interpretation of such data.

REPORT OF SECTION 4

Availability (Accessibility and Vulnerability)

Chairman: G.V. Howard
Rapporteur: M. Blackburn

1 References

MP/4; IP/2; EP/9, 11, 14, 15, 17, 27, 31, 34, 38; SS/1, 6, 9, 10, 11, 12, 13, 14, 15, 16, 18, 21

2 Discussion

Abundance refers to the whole population; availability refers to the portion of the population that is within the geographic range of the fishery; and vulnerability refers to the portion of the available population that is taken by the fishing gear. Availability depends on the distribution of the fish and on the range of the fishing vessels; vulnerability depends on the distribution and behavior of the fish and the fishermen, and the effectiveness of the fishing gear. Availability and vulnerability are considered to be measurable, but present knowledge about them is mainly qualitative as far as the tunas are concerned.

Fluctuations in availability are thought to be large in several tuna populations; they elevate production costs in absolute sense and pro rata; they must be allowed for in any studies of abundance; they reflect the response of the population to changes in the oceanic environment and possibly technical changes in the fishing fleet. Their analysis calls for fundamental and comprehensive studies of oceanic and atmospheric features and processes, detailed catch and effort data and the study of certain features of the biology of the species concerned. Such investigations, hitherto concentrated in the Pacific, are a prerequisite for the measurement and efficient prediction of changes in availability, required by scientists studying the population dynamics of the tunas and the fishing industries harvesting them. The forecasts of availability attempted at present are few, empirically-based, and predictive only of gross changes.

Several investigations have empirically identified the approximate limits of distribution of some tuna populations and related them to surface isotherms. In some instances, the correspondence remains close over many changes in the positions of the isotherms. The meeting emphasized, however, that nothing is known about the physiological mechanisms involved, in the reaction of tunas to temperature relations within one species, depending upon locality, age, and type of activity (e.g. feeding or spawning). It was emphasized that tuna distribution may be limited in some instances by temperature-connected features or properties rather than by temperature itself.

Whereas temperature has proved moderately useful in interpreting limits of distribution of tuna populations, it has not generally been helpful in explaining spatial and temporal differences in abundance within population ranges except in a gross way. The opinion is widely held that these differences reflect differences in abundance of suitable prey, although supporting statistical evidence is meager. In some parts of the Pacific, high tuna concentrations tend to be associated spatially and temporally with features such as divergences, thermal anticlines, eddies, convergences, banks, and islands; some of these features are known, and others are suspected, to be good for producing or concentrating biota on which tuna form feeding aggregations. It was noted that such biota could be displaced in time and space from the point of the original enrichment processes.

Another line of work in progress in the Pacific seeks to explain differences in tuna distribution by considering certain populations to be more or less associated permanently, or at least during extended periods of their life, with specific "water masses" or "water types", which are recognizable by their

temperature-salinity relationships.

General observations, on the study of availability of tuna in relation to environment, included the following:

(1) It is difficult at present to collect concurrently quantitative data on ocean properties on the one hand and tuna catch and effort data on the other, in a form suitable for detection of cause-and-effect relations, because fishing vessels work independently of oceanographic vessels. It would be of immense value if oceanographers had some simple means (such as sonar) to measure abundance of tuna in the course of their other activities.

(2) Even when meaningful relations between tuna and ocean properties are observed, it may be advisable to consider them as simple manifestations of relationships involving complex features and processes.

(3) Detailed understanding of such features and processes generally will be required if the objective of the work is to predict availability of tuna from some fundamental and easily-measured property such as atmospheric pressure. It is necessary to investigate not only the mechanisms, but also the time constants involved; such investigations are difficult, but some useful progress has already been made.

Investigations of tuna behavior, to understand and improve the effectiveness of present fishing methods and to suggest new techniques, are recent in origin and few in number. It is suggested that the presence of a shoal thermocline, within the depth range of a purse-seine net, may slow or even prevent the escape of tuna during the pursing operation. It is also thought that netting may be more effective than hooking in turbid waters, where the fish may not readily perceive the bait. Investigations on these and similar matters are in progress or are contemplated.

3 Future Work

Past investigations have provided a reasonably adequate picture of the average distribution of certain Pacific tunas in relation to gross features of the ocean circulation and the distribution of various properties. Although more work of this kind is needed in most areas, it is considered that future efforts should concentrate more upon the study of temporal variations of both large and small-scale features of the ocean.

Temporal changes in oceanic and atmospheric properties and features and their interplay are imperfectly known in most regions, because of the obvious limitations of research ships for covering the ocean with the needed frequency of observations. Other kinds of vessels provide good coverage of sea surface temperature and meteorological observations only in particular areas, e.g., on commercial steamer tracks. Masters of fishing vessels should materially assist in this area more than they do now. They should be encouraged to do so to increase the geographic coverage of such observations and to make other observations routinely, particularly bathythermograph casts. There is an urgent need for anchored unmanned stations, capable of recording and eventually telemetering serial observations made in the layer of the ocean inhabited by tunas and in the atmosphere above it, in selected areas. Since such stations are unlikely to be available in the numbers required and with all the necessary capabilities for several years, much of the urgently needed work on temporal changes will have to be done by research ships and fishing vessels. Such work (e.g., the running of synoptic property-measuring surveys over large parts of the ocean with several ships, at different seasons of the year) could probably be combined or alternated with studies of special small-scale areal features and processes in particular locations.

There is general agreement that charting and monitoring of the distribution of properties must occupy major attention in most tuna resource areas for the immediate future, but that investigation of small-scale features and special processes can be intensified simultaneously. Also, as work in these areas proceeds, a gradual shift to the study of dynamic processes which produce the distributions and the principles which govern them must follow.

The small-scale features include the divergences, convergences, and other incompletely-studied situations mentioned. The relation of tuna concentrations to these features needs to be better known, so that forecasts can be

made with more assurance and the nature of the connections demonstrated in such a way as to facilitate the understanding of similar situations elsewhere.

Although the meeting was unable to discuss the technical characteristics of fishing units that play a part in determining availability, or those characteristics of gear and method that play a part in determining vulnerability, it recognized the importance of these matters and recommended development of research on them.

4 Cooperation

The suggested program of future oceanographic research coupled with extensive meteorological studies (especially the moored station networks and the multiship surveys) is so vast as to require the participation of several nations and of all segments of marine science within each nation. Researchers concerned with tuna, biologists and oceanographers alike, should expect and plan to make the necessary investigations in cooperation with marine scientists who serve other interests of mankind (including the pursuit of knowledge for its own sake), within and beyond their own national boundaries.

5 Suggested Resolutions

Many tuna populations and the environmental features with which they are believed to be associated, occur on a geographical scale that may defy the efforts of scientists of any one nation to describe, understand, and predict them. It is strongly recommended, therefore, that investigations be undertaken, wherever and whenever possible, in cooperation with the rest of the scientific community in each of the several nations concerned with tuna research. An example of the effort envisioned is the multi-nation ocean research project which is to begin in the Tropical Atlantic Ocean in 1963 under the sponsorship of the Commission for Technical Cooperation in Africa South of the Sahara/Scientific Council for Africa South of the Sahara (CCTA/CSA), the United States, and the international scientific community through the Intergovernmental Oceanographic Commission. Attention is also drawn to another such multi-nation, multi-discipline endeavor which is in the formulative stage, the proposal of the Eighth Eastern Pacific Oceanic Conference (EPOC) for a cooperative survey of the Eastern Pacific Ocean. Such cooperative ventures are logical extensions to earlier joint oceanographic surveys, such as NORPAC and EQUAPAC, which were successfully undertaken to the mutual benefit and satisfaction of all concerned.

REPORT OF SECTION 5

Behavior and Physiology

Chairman: J.J. Magnuson
Rapporteur: K.F.W. Tiews

1 References

MP/5; EP/2, 25, 26, 36, 37

2 Discussion

2.1 Feeding Behavior

Bluefin are difficult to catch on hook and line off the coast of California unless they are mixed with albacore or yellowfin. In surface schools of albacore and bluefin, the bluefin bite readily. Perhaps the feeding behavior of the albacore or yellowfin stimulates the bluefin in a feeding response.

Bluefin in the North Sea are attracted with dead chum or bait fish even when abundant herring are present. North Sea bluefin were occasionally observed below the thermocline in temperatures of 6°C to 8°C. Sonar traces demonstrated that they moved up through the thermocline to the surface where the temperature was 14° to 16°C, when attracted by the chum. This is one of the few observations of tuna penetrating through a thermocline.

Evidence from Norway suggests that "breezing" schools of bluefin tuna are feeding on small herring less than 6 cm. and "boiling" schools on larger herrings, above 20 cm.

The schooling drive or the reproductive drive might supersede the feeding drive either when the feeding drive is partly satiated or in the reproductive season. It is known that spawning Pacific salmon do not feed, and Atlantic bluefin are also believed to be less responsive to food stimuli during their reproductive period.

2.2 Schooling Behavior

Wahoo (*Acanthocybium solandri*) has now been reported to be found in schools and can be included in the growing list of scombrids which have been observed to exhibit schooling behavior. The situation is essentially unknown in *Allothunnus*, *Grammatorcynus*, *Gymnosarda*, and *Orcynopsis*. Although schooling is believed to be a visual response, tuna schools have been observed at night in the dark of the moon. Both yellowfin and skipjack have been captured with purse seines at night in the eastern tropical Pacific. Sometimes these schools are visible owing to the bioluminescence of the plankton. On other occasions night schools are found in the absence of bioluminescence, by shining a beam of light into the water. When the light rays hit the night school, the startled reaction of the tuna stimulates bioluminescence, which make the schools visible for a short time. Other evidence for night schooling is the fact that schools are observed to be already formed in the very early morning. Although some incident light always seems to be present at sea, these observations indicate that other sensory systems may play a role in schooling orientation. Unpublished work on the lateral line done by T. Walker indicates that this sensory system may be involved.

A suggestion was made that the role of schooling as a behavioristic element of the nexus of circumstances determining distribution (both with respect to limits and to density contours) would be worthy of further study. A special aspect of this matter was the length of time in which a school persisted.

With regard to the permanence of a school as a social unit, Australian fishermen fishing bluefin believe that they can follow the same school for an extended period. Tagging results on bluefin tuna from the western side of the Atlantic indicate that the schools maintain themselves for long periods of time. On the other hand, yellowfin and skipjack tagged at the same location have been recovered widely separated to north and south of the tagging site in the eastern tropical Pacific, and bluefin tagged in the western Atlantic mixed off the coast of Norway after a period of roughly three months with bluefin schools which originated in the eastern Atlantic. Specimens of yellowfin tuna and of skipjack which had been tagged, in each case, in the same school, have been recovered from several different schools within a few days.

2.3 Associations

Referring to Experience Paper No. 25 on the schooling behavior within aggregations composed of yellowfin and skipjack tuna, a difference of opinions was expressed as to the permanence of a mixed school relative to the permanence of a pure school. It was debated whether a mixed school was a juxtaposition of two or more monospecific schools due to some drive other than the schooling drive and whether a mixed school would tend to break up into mixed schools or monospecific schools.

A skipjack held in captivity schooled with a mahimahi (*Coryphaena*) when it had no skipjack with which to school. Likewise, two yellowfin and three little tuna (*Euthynnus yaito*) were observed to school by species until one of the yellowfin disappeared from the tank. Thereafter the yellowfin joined the school of little tuna.

Bluefin tuna in the northwestern Atlantic occasionally feed on butterfishes (*Poronotus triacanthus*) which are associated with sargassum weed patches. Bluefin passed from patch to patch and would even make feeding dashes through the patches while chasing prey. Subsequently some of these weeds were actually found in the stomach contents. Bluefin tuna were also observed associating with the blue shark for periods up to one hour in duration, and blackfin tuna with whale sharks.

2.4 Migratory Behavior

Available evidence does not demonstrate which sensory systems are used by tuna to orient during their extensive migrations. Just because tuna are found within certain temperature limits, this does not prove that they are able to detect and orient to temperature gradients. Occasionally herring during their migration pass through a wide variety of temperatures in the eastern Atlantic, where they cross the Gulf Stream on their way from one fishing ground to the other. Although a lowering in temperature by 2° C increased the activity and altered

the behavior of anchovies, it was questioned whether a pelagic species could remain in an area of preferred temperature without a sense of direction orientation. Migration orientation in salmon and other marine organisms suggests that more than one sensory system may be involved.

2.5 Reproductive Behavior

A brief reference to reproductive behavior can be found in Species Synopsis No. 12. Fish in reproductive condition in purse seines and hook fisheries are rare.

2.6 Sensory Systems

Although visual acuity cannot be adequately calculated from the results of histological studies of the retina at present, work on the clupeids indicates that some interesting ecological and behavioristic inferences can be drawn from histological studies. Perhaps after visual activity has been determined for a number of species by conditioning experiments, the cone and rod densities can be associated with certain visual abilities. A study of the absorption spectra of visual pigments might also lead to inferences on the behavior and ecology of tuna.

2.7 Physiology

Recently published data by I. Barrett of the Inter American Tropical Tuna Commission indicate that a high production of lactic acid in yellowfin and skipjack tuna results from the handling involved in tagging operations. The build-up of lactic acid results from the handling and not the insertion of the tag. Skipjack appeared to have a higher rate of lactic acid production than yellowfin. The work of other investigators on salmonids shows that mortality due to handling is associated with lactic acid production.

Some of the variations in the quality of tuna food products are believed to be dependent on the physiological condition brought about by the way in which the fish dies on the fishing gear. Perhaps fishing gear which result in a rapid death would provide a better quality product. The use of electricity to kill the animals without a long period of struggling was suggested. German scientists are exploring this possibility in purse seine fishing for sardines and in other fisheries.

The reasons for the occurrence of green cooked tuna observed from certain catches of yellowfin tuna made in Africa and the eastern tropical Pacific are not known.

3 Future Work

The most striking deficiency in our knowledge of tuna behavior is the lack of direct observations on living specimens both in the wild and in captivity. In order to understand and predict the behavior of tuna, these observations are needed.

Since the major problems in the direct observation of tuna result from inadequate technology and observation facilities, it is recommended that continued efforts be made to test and to further develop the available tracking devices, such as radio tags and sonar, and that construction of shore-side tanks or marine enclosures large enough to study the behavior and physiology of tuna be encouraged, that continued efforts be made to improve method of direct observation of tuna at sea, including observations from airplanes, helicopters, submersibles, and surface vessels, and that research on the histology and anatomy of the sensory systems of tuna be expanded.

We would like to emphasize that most studies of behavior require direct observations of the fish or the fish school. The methodology of European ethologists is suggested as a fruitful approach.

4 Cooperation

International cooperation such as is needed in the studies of population differentiation does not seem to be necessary in the field of behavior and physiology studies at present. The exchange of ideas and information is, of course, highly desirable.

5 Suggested Resolutions

Resolutions to standardize methods and to enlist international cooperation are premature. Yet, we would like to envisage a continued expansion of behavior and physiological studies on scombrid fishes.

REPORT OF SECTION 6

Fishing Gear

Chairman: J.L. Kask
Rapporteur: W.E. Ripley

1 References

MP/6; EP/1, 4, 10, 19;
All Species Synopses

2 Discussion

2.1 General

Within the past three decades, the world tuna fishery has exhibited one of the most remarkable industrial developments ever demonstrated. Several factors have contributed to this growth among which has been the substitution of bland vegetable oils for the natural fish oils in the canned product, a greater acceptance of canned tuna on the world market and by evolution and revolution in the fishing techniques of Japan and the United States. The dynamic changes occuring in fishing techniques have made the industry keenly competitive without any fishing method remaining dominant for any great period. Favorable economic factors in many nations have spread the market throughout the world, leading to increasing demand, with a resulting stimulus for even greater production. The result is now laid before us at this conference, a world-wide interest in the exploration and exploitation of the scombroid resources of the seas and in concern for their rational and orderly utilization.

Fishing methods for tuna contribute to the complex interdependence of the many parts composing the overall fishery, relating to location of catch, method of operation, economics and a host of other reacting conditions. One basic consideration that cannot be overlooked, however, is the fact that the efficiency of the fishing methods dictates the economy of the industry.

Although processing methods were not considered an appropriate subject for extended discussion under this section, there was general recognition that the processing methods available (particularly to areas where market conditions were limited) had a definite effect upon the demand for fish. Various methods were discussed during the session, of which the *katsuobushi* (hard dried fish) was most often referred to as a potential one for stimulating consumption in undeveloped areas.

It was generally conceded that the improvement or development of methods adapted to less sophisticated fishing techniques and fisheries would result in a significant increase in world catch of tunas as well as provide economic benefits to the primitive fishermen. The great dependence of many thousands of one and two-fish-a-day fishermen throughout the world upon limited techniques and resources makes this an appropriate area of humanitarian concern for this section and this conference. It was pointed out that assisting the catching capacity of a one-fish-a-day fisherman to two-fish-a-day was an increase in capacity by a factor of two. To these producing units such increases would be as significant as the long-line or purse-seine-power-block were to the more sophisticated segments of the industry and to the same degree.

2.2 Major types of Fishing Techniques

It was generally agreed by the meeting that local conditions dictated the selection of techniques that might be best suited for any given area. Biological, ecological and economical differences would seem likely to preclude any specific generalizations.

2.2.1 Comparative Efficiency between Line and Net Fisheries

The classification of passive and aggressive gear by type was not considered necessarily appropriate. It was pointed out that whereas vessel fares may result from either hooking or netting, the art of catching fish with either gear involves the same basic fishing skills. Generally, these are the ability to locate adequate aggregations of fish, the knowledge of holding them in place and an understanding of their behavior. The success of the final act of capture differs only by method used.

2.2.2 Pole and Line Fishing

Up until the last decade, pole and line fishing produced the bulk of the world's supply of tuna. With the advent

of the Japanese high seas longline operations, the advantage of this method reduced the price of fish and forced great change in the major pole and line fishery. Part of the stimulus for this upset was due to competition for skilled labor which fact can be considered a determinant factor in the operation of fishing fleets. In California, when the price of tuna fell to a level resulting in less wages to the fishermen than could be earned in shore-side jobs, the fishermen stopped fishing.

The pole and line method is used extensively for taking considerable quantities of yellowfin, albacore, and skipjack. Although supplanted to a large degree by more efficient methods for yellowfin and albacore in some areas, pole and line fishing remains the most successful method for taking skipjack in some areas. In areas where the thermocline is deep, it is considered the most consistently productive.

However, the use of pole and line fishing is generally limited to moderate-sized fishing vessels fishing coastal areas within range of suitable bait sources. When the technique is used in conjunction with a water spray system, there is evidence that the spray operation contributes to the success of fishing. Spray systems have not been proven effective in the eastern Pacific.

Bait is always a problem, making the success of this method dependent upon a secondary set of factors, that of bait supply. In many areas of the world where pole and line fishing could be conducted, bait limits its use. Successful research on artificial or culture means of producing bait could supply an important stimulus to this method of fishing.

The coming decade should see the development of a large locally supplied modest-sized pole and line vessel fishery in the tropical seas throughout the world. Although the quantities of tuna to be expected from this development are not expected to be spectacular in individual landings, it will contribute to the economic and nutritional benefit of the affected regions.

2.2.3 Trolling

Throughout the world, trolling is one of the most universal methods of taking tunas, particularly albacore, yellowfin, bluefin, and skipjack. Fleets of modern highly-mechanized vessels sweep the coastal seas landing great tonnages of fish and returning considerable wealth to their operators.

Great numbers of simple sailing rafts and canoes collectively land thousands of tons of tuna but bring only bare existence to their operators.

Jig trolling is a simple method that does not require a high degree of skill from the operator. It can be carried out almost anywhere with the use of native materials and methods.

Combinations of speed, jig or bait and proper environment conditions control the success of individual operations. Minimum trolling speeds govern the catch, both from the species taken as well as limiting operational efficiency. As speed increases to over six knots, the proportion of tunas to other species increases. Greater speeds, however, require heavier gear and installation of shock absorbers in the system. Wire leaders are considered important to prevent severing the lines at the point of lure attachment.

Vessels troll with from one to seventeen lines, depending upon their degree of mechanization. Some bait vessels use trolling to locate schools of fish which are not showing on the surface.

The terminal lures are considered a very important part of the method. Modifications which could increase the success of the small-sail trolling operator would make an important contribution to increased capture and to the utilization of local resources.

In some areas, electrical current is being experimented with to assist in killing large fish quickly.

Future development in many areas of the world will be with troll gear. Its advantages and simplicity have been outlined above. It is free from bait limitations, can operate at any required depth and can be prosecuted with one or more lines with daily rewards varying from one fish to many tons.

2.2.4 Longlining

Large fish, widely scattered in deep, mid-ocean water and generally unavailable to other forms of fishing are the source of the long lines supply. There is some evidence that this method has attained its peak in some areas with catch per unit of effort declining.

Although generally conducted from large sea-going vessels, longlining just above the thermocline is carried out in native canoes in some areas.

2.2.5 Drift-net fishing

Conference discussion of this method was expanded to include surface gill nets. Concensus of experience with drift-net operations indicated that it was not very successful. Some evidence was presented that gill-nets were useful for capturing bonito and for determining the abundance of albacore. Caution was suggested before disregarding the drift-net as ineffective. Reference was made to the recently developed successful operation of this gear in the high seas salmon fisheries.

2.2.6 Purse-seining

An old method of fishing dating back to the past century, purse-seining has had its oscillations of popularity. Development of synthetic materials combined with the use of power blocks have contributed to its recent adoption by large vessels. Its practical use seems confined to ocean areas where the thermocline, and hence the tuna, are close to the surface. The increase in efficiency of the modified system once again has made the method competitive in the world fishery.

Predatory sharks have been found to cause significant damage to purse-seine gear and its catches. Methods of control or abatement of shark interference would offer considerable relief and help to the industry.

2.2.7 Set-net fishing

Although seemingly productive under favorable local conditions in various places of the world, traps are not indicated to produce a significant proportion of the world's tuna supply. Their sessile nature precludes their facile pursuit of their mobile piscatorial prey. They are, nonetheless, important in their contribution to local economies.

3 Future Work

Several directions of effort seem likely to benefit the tuna fishery. They are:

1. Develop methods to harvest skipjacks. It was the concensus of the conferees that the oceanic populations of skipjack represented an underutilized resource
2. Delineate the areas of tuna abundance
3. Expand and improve the detection of tuna by use of modern electronic gear
4. Observe the behavior of the many species of tuna and the predatory sharks
5. Determine the environmental conditions in which the tuna live
6. Investigate the relationship of sea birds to schools of fish
7. Consider the selectivity of gear and its potential contribution to more efficient fishing and to conservation
8. Study natural and artificial baits
9. Stimulate the scientific cooperation of the sophisticated fishermen
10. Increase the efficiency of the unsophisticated fisherman

REPORT OF SECTION 7

Statistics of Catch and Effort

Chairman: M.B. Schaefer
Rapporteur: G. Saetersdal

During the main sessions on July 10 a working group was formed to discuss problems related to compilation, standardization and exchange of data. This working group met on July 12 and its findings are included in this report.

1 References

MP/7; EP/7, 9, 11, 12, 15, 17, 21, 29, 33; SS/16; IP/4, 8

2 Discussion

2.1 Introduction

There is a general need for improvements in this field through a) a better coverage, b) more detailed data, and c) standardization of methods. This need has already been acknowledged in several previous regional meetings on tuna research. An example of similar efforts to improve the collection and compilation of fishery statistics is the work in the North Atlantic Region by the ICNAF/ICES/FAO[1/] Continuing Working Party on Fishery Statistics, and note was taken on the report that has been issued concerning the activities in this area.

2.2 Uses of statistics of catch and effort

The uses to which the data can be put can conveniently be classified as follows: a) Measuring of changes in abundance in space and time; b) Measuring of the success of the fishermen in locating their catches and c) Research on population dynamics. A number of the papers submitted to the meeting compares abundance changes and environmental factors e.g. Experience Paper No. 9 from the Indo Pacific, Experience Paper No. 11 from Hawaiian waters, Experience Paper No. 15 from the North Pacific, Experience Paper No.17 from Pacific, Experience Paper No. 29 from the tropical Atlantic and Experience Paper No. 33 from the eastern tropical Pacific. Besides these contributions to this meeting a quite extensive recent literature can be cited on such ecological use of tuna catch statistics from Japanese waters, from the equatorial Pacific and from the eastern Pacific.

Great interest is attached to the use of catch and effort statistics in population dynamics studies. The type of data needed varies somewhat with the kind of model that is applied. However, total catch and an estimate of total effort are basic requirements. The meeting's attention was drawn to a model recently developed by J.A. Gulland of the Fisheries Laboratory, Lowestoft, England, which describes the effect on the catch of changes in gear selectivity. The data needed for this model is essentially the size-catch curve, an estimate of E (expectation of capture), and some knowledge of the size selectivity of the fishing operations. It was pointed out that regulation of the minimum size of capture through control of gear selectivity may be an important tool in insuring rational exploitation. Knowledge of the selective processes in the various types of tuna fishing is however poor, and work should be encouraged in this field.

Analysis of the state of tuna stocks based on catch and effort statistics has been attempted only for two populations, viz. the yellowfin and skipjack of the eastern tropical Pacific. While adequate data for such analysis may perhaps exist also in a few other areas, generally there is a regrettable lack of the necessary basic information. It was recognized as one of the primary functions of this meeting to encourage the collection of data needed for stock analysis. In the only area where such work has been applied, a marked effect of the fishery on the stock of yellowfin tuna has been demonstrated, but it has also been shown that the stock of skipjack has been little affected by the fishery. It is thought probable that the level of fishing intensity may already be critical also for yellowfin tuna, and perhaps other species, in several other areas.

2.3 Requirements

Although it was recognized that requirements may vary somewhat for different species and regions, universal rules could in most cases be agreed upon.

2.4 Coverage

On catch coverage must be complete, whereas information on catch per unit of effort can be collected from a representative sampling system. Total effort can then be estimated by dividing total catch

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1/ ICES - International Council for the Exploration of the Sea

ICNAF - International Commission for the Northwest Atlantic Fisheries

by the catch per unit of effort. Both catch and catch per unit of effort should be specified by gears.

2.5 Area

The minimum requirement for total catch and total effort is by areas at least as small as those occupied by unit populations, and preferably by five degree areas of latitude and longitude. In reporting catch per unit effort data areas must be much smaller to allow ecological studies and studies of migrations and movements, and it was agreed to suggest areas of one degree of latitude and longitude for these data. Generally it was considered to be a great advantage to make use of reference to latitude and longitude in area reporting because of compatibility with oceanographic data reporting, in which field there is a universal movement to key observations in this manner. However, it was pointed out that in shore-based coastal fisheries such as the fisheries for *Sarda*-species on the western coasts of Africa and South America, port of landing will usually be sufficient to indicate locality of catch because of the short range of the fishing fleets.

2.6 Time

In some special investigations, such as the study of the feeding migrations of the bluefin tuna in the northeast Atlantic, reporting of catch on a weekly basis has been found useful. Similar small-time units would often be required for ecological application of catch and catch per unit data. For stock assessments of the rapidly-growing tropical tunas it is considered necessary to have monthly data of catch and catch per unit of effort, while in temperate zones such data can probably be compiled on an annual basis. It was generally recommended to use the month as the time unit wherever possible.

2.7 Methods of collection of data

When catch is derived from landing data, and this is very often the case, the importance of a proper recording of area of capture was stressed. If information on area of capture is only sampled, bias must be avoided preferably by combination with log book sampling of vessel operations.

Discussion under this item centered on methods of collecting catch per unit of effort data. The use of vessel log books was recommended for fisheries where the vessels stay out for more than one or a few days. Several workers reported on successful use of such log book systems. The full cooperation of the fishermen may be difficult to obtain, but this can be facilitated by 1) Designing the books in such a way as to be of practical use for the fishermen; and 2) collecting the data by visiting inspectors who copy desired information from them on board the vessels. These inspectors also can promote contact and understanding of the work --- in short-range fisheries use can be made of company records, sales slips or interview systems. A possible source of bias in log book records is that the distribution of the log books is selective towards the keener and more successful fishermen. The log book data must be identifiable by vessels so that adjustments can be made for the influence of the various vessel characteristics on the fishing power to enable an estimation of catch per unit of effort and total effort in standard units. Similarly when more than one gear is used, comparable studies of the catch per unit of effort of the two gears should be made, or total effort should be estimated directly in units of one of the gears by raising the effort by catch ratios.

3 Suggested Resolutions

3.1 Standardization of methods and exchange of data

Note was taken of Information Paper No. 4 and Information Paper No. 8 on this subject. It was agreed in principle that the national, regional and world-wide systems of compiling and disseminating data that operate at present are in urgent need of coordination and perhaps reorganization. The following points were agreed upon and were suggested as resolutions from the meeting:

1) That a uniform system of reporting total catch and catch per unit of fishing effort on all species of tunas, wherever caught, should be developed for use by all nations participating in these fisheries.

2) That accurate records should be kept, for each gear type, of total catch by weight of each species of tuna, and of other species taken at the same time, geographically as far as possible in five degree areas of latitude and longitude or,

when such accurate locations are not available, to be identified with larger geographical areas within which the smaller geographical units can be grouped but that such larger areas should not be larger than the area of distribution of unit tuna populations.

3) Estimates should be made of the effort expanded in taking the catch referred to in #2: For this purpose log book records of effort and as associated catch by species by weight (and where possible by numbers) for representative samples of the fishing fleet should be used. These records should be compiled in one degree areas of latitude and longitude for each month.

4) That the log book records should be classified by gear type and by vessel size or other characteristics associated with fishing power or be standardized before reporting, provided a detailed description of the method of standardization is published with the data.

5) That all data concerning total catch and log book records of catch and fishing effort should be compiled by month of catch so far as possible.

6) That each nation develop these records from its own fleets and compile and distribute the monthly records after the end of each quarter (using January, February and March as the first quarter etc.) issuing preliminary reports to all interested nations and organizations as soon as practicable after the end of each quarter.

7) That the Food and Agriculture Organization of the United Nations should be requested

(a) to assume responsibility for coordinating and developing such records, assisting nations which require help in developing their methods of recording and reporting data, providing continuing review to insure world-wide uniformity and accuracy of the data, and promoting rapid distribution of the preliminary quarterly reports.

(b) to compile and publish on an annual basis, summaries of these data from all countries, including all corrections and additions to the preliminary quarterly reports.

Furthermore, the working group decided to attach some comments to some of the above points. Thus, it was agreed that the five degree areas described in 2) should preferably be standardized, and it was noted that both Japan and the Inter-American Tropical Tuna Commission (IATTC) make use of the areas designated by 0 to 5 degrees, etc., both by latitude and longitude, and thus this system could conveniently be chosen.

It was noted that, due to duration of trips, month of capture for landings not accompanied by log-book data may sometimes be difficult to record. The best approximation should then be applied.

In some long-range fisheries there is also a considerable delay in the compilation of the complete data. In such cases, an indication of completeness should, if possible, be given in the preliminary quarterly reports.

It was furthermore stressed that in developing this world-wide system of data exchange proper use should be made of the existing regional centers of data collection, such as the IATTC and the ICES, so that duplication of work is avoided. In requesting the cooperation of the interested nations the FAO should make it understood that, if convenient, the work can be effected through existing intergovernmental commissions.

After discussion of L.P.D. Gertenbach's suggestions for a world-wide system of reporting tuna fishery statistics, Information Paper No. 8, it was agreed that the form he suggested will probably not be very suitable for the tuna fisheries. Essentially, the data need to be reported in such a form that catch and effort can be associated for each species and with details of the time and area stratification mentioned above. It was suggested that FAO should make a study of the most convenient method of reporting the data indicated in 2 - 5 above.

In doing so, due consideration should be given to systems involving data processing machines. Such systems are already in use in national and regional tuna research centers and exchange of data could be effected either by copies of machine read-outs, or, if the systems are compatible, by exchange of duplicate punch cards. The FAO should promote the use of compatible systems.

It was finally noted that the annual summaries of data prepared by FAO should be by such unit areas as are judged useful for scientific studies. Details of this could be decided on by consultation with a suitable research panel of tuna experts.

REPORT OF SECTION 8

Future Lines of Research

Chairman: W.M. Chapman
Rapporteur: E. Postel

1 References

MP/8, 9, with reference to MP/1A, 1B, 2, 3, 4, 5, 6, 7;
SS/16

2 Discussion

Before the second world war, the question of tuna (*sensu lato*), and, consequently, tuna research, was essentially a national one. Since the war, however, the significance of tuna has developed prodigiously and is now a matter of international concern. The consumption of tuna has doubled in ten years, having risen from 400,000 tons in 1950 to 800,000 tons in 1960. It is probable that it will again double in the present decade. It is with this perspective that research problems must be approached.

Oceanographic programs have been drawn up to be put into operation in all of the seas of the world.

Juridical discussions of problems of territorial waters and of the conservation of living resources (Rome, 1955; Geneva, 1958)[1/] have been, and will continue to be discussed. From all of these matters, though they are not directly related to the subject of tuna, we may glean inferences of interest to our task. It is necessary, therefore, to take account of them and to orientate our research within a general context.

Within this context the problems which directly concern us are species identification, population studies, especially in respect to dynamics and conservation, and requiring as precise as possible an approach to the primary phenomena such as recruitment, growth, and mortality, and the secondary phenomena which are a result of human activities, of which, naturally, fishing activities are the most important.

The preceding sections have shown us other paths leading to research. These have their rightful place of importance but what has just been evoked herewith appears to be crucial on two accounts, both the scientific and the economic.

In the course of these last few years, the development of fleets has been orientated in the following two basic directions:

a) Purse-seiners

b) Longliners

By reason of the rapid advance of the underdeveloped countries, it is probable that in the future we shall witness not only the existence of long-range purse-seiners and longliners, but also an increased number of small vessels using various types of gear. Undoubtedly, all types of vessels will use a chain of cold storage plants for transshipment purposes. We must bear this in mind in orientating our future research.

The questions of special importance have been raised by the regional

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1/ International Technical Conference on the Conservation of the Living Resources of the Sea, Rome, 1955. - First United Nations Conference on the Law of the Sea. Convention on Fishing and Conservation of the Living Resources of the High Seas, Geneva, 1958.

conferences at Dakar, Honolulu, and Mandapam Camp, and it would be advisable to convoke others. The creation of an Inter-African Tropical Tuna Commission, modelled on the Inter-American Tuna Commission, was envisaged at the first of these conferences and deserves special attention. The utility of such a commission can leave no doubt in our minds.

Following the Chairman's exposition on the major lines developed, the discussion was concentrated mainly on the means of implementing them.

The term "conservation" should be understood in the sense accorded it at the Geneva Conference (1958). Its definition is therefore as follows:

"As employed in this convention, the expression 'conservation of the living resources of the high seas' means the aggregate of the measures rendering possible the optimum sustainable yield from those resources so as to secure a maximum supply of food and other marine products. Conservation programmes should be formulated with a view to securing in the first place a supply of food for human consumption."

The care that this definition expresses to consider the problem from the angle of human consumption has many worthy defenders who have convinced the assembly of the need to correlate research of an economic nature with the biological research that has been outlined above. Interesting considerations have been developed on the relationships between catches, fishing activities, maximum yield and financial yield (which do not necessarily coincide). The problem, which is relatively simple in the case of one species, quickly becomes complicated in the case of many. Extrabiological elements, (notably meteorological and hydrological factors) can have a bearing. The means of approaching a problem differ according to the latitude, and the results of studies made in a temperate environment are not necessarily transposable to a tropical environment. However, excellent examples are to be found in the work done on the clupeoids of the North Atlantic and the Northeast Pacific. As far as predictions are concerned, it is necessary to be prudent. The relationships between tuna and temperature or tuna and their food supplies are not perhaps as close as we are often given to think. Moreover it is not obligatory that these predictions be based upon observations made on the level of schools. It appears that distance measurements, established at points which control all of the oceanographic features of a given area, can be of far superior value, always on the condition that they be continued for series of long duration periods.

Periods of abundance, as well as of scarceness, do not appear to be cyclical. However, they do follow a pattern, which should permit great improvements in short-term predictions.

On the whole, it would be helpful to augment all types of observation, particularly in tropical countries; but here one encounters a subordinate problem almost as serious as the main problem, that of recruiting researchers.

How can one inspire the necessary dedication? How do we mold a scientist? And how can he be kept absorbed in his work? The challenge of unresolved questions requires unfailing energy and talent if a solution is to be found. Going beyond the everyday approaches, such as scholarships and paid training periods, whether they be sponsored by the government or by industrial groups or carried out by organizations already in existence, the idea of creating a maritime university (sciences to be applied to fishing) in normally developed countries, and in regional centers in underdeveloped areas, has met with general approval.

The example of Japan, which has three highly specialized divisions of personnel training (navigators and fishery technicians, biologists, technologists, and processing specialists), shows that the biologist find placement difficult and rarely have outlets other than administrative positions (outright administration or research administration within the framework of governmental organizations).

The association of the professionals (ship-owners, industry and fishermen) with research has long been called for and considered indispensable. Too often there exists between them and the researchers a gulf which must be bridged, whether it be by frequent contacts or in a much more efficient manner, by the formation of certain elements at the

level of those technicians assigned to oceanic observations. It is certain that if the fishermen had a better understanding of the aims of the scientists they would be far more ready to lend their assistance. Examples of fruitful collaboration do exist. It is extremely important that they be increased and that the participation of all professionals be solicited for a generalized research program.

And finally the role of the field of statistics has been much discussed by Section 7. We can but agree entirely with its findings.

3 Future Work

Apart from the broad lines defined by the Chairman and discussed in his Methodological Paper No. 9, the Meeting put forward several main ideas which can be summarized as follows:

a) The need to correlate biological research with economic studies. Should a conflict arise between maximum productivity compatible with stock conservation and financial return from fishing operations, priority should be given to maximum productivity.

b) The need to develop a system of making conservative predictions regarding those factors which control the presence of fish in a given area. Observations obtained in fishing areas may be used providing that they be carried out on the basis of periodic studies over considerable periods.

c) The need to attract and train additional scientists and to utilize to the fullest the competence of those already at work. Isolation has shown itself to be a sterilizing factor and must consequently be avoided.

d) The need to establish the professionals (industry, ship-building, and fishermen) in close relationship with research. There ought to be constant contact between these different groups and the scientists themselves.

4 Cooperation

International cooperation is admittedly an indispensable factor for success, It can serve:

a) On a regional basis -- we note here with admiration the excellent results of the Inter-American Tropical Tuna Commission; -- we observe with satisfaction the announcement of the creation of a parallel commission for the Atlantic area off Africa.

b) On a world-wide basis -- it is hoped that we witness here the inception of an organization of general competency, the need for which has been unanimously recognized and the creation of which has been proposed to the Director-General of the FAO in a separate recommendation.

5 Suggested Resolutions

(See "b" above and the text of the proposed recommendation).

(See also in all other recommendations the suggestions for future research).

REPORT OF WORKING GROUP 3

Stock Transfers

Chairman: G.L. Kesteven

Some species exist as single stocks or populations; other species exist in two or more stocks. A unit stock has been defined as [1/] "a relatively homogeneous and self-contained population whose losses by emigration and accessions by immigration, if any, are negligible in relation to the rates of growth and mortality." Consideration must be given however to cases where there is some significant measure of exchange between stocks which, for various reasons, are regarded as unitary. Strictly speaking, taking the definition offered for unit stock, if a stock which has been regarded as unitary is found to have significant gain or loss by migration, its limits should be extended until all or nearly all the units participating in those exchanges are included within the stock and there is no longer a significant exchange between it and some unit outside

1/ Spec.Publ.I.C.N.A.F., (2), 1960:8-9

of it.

However, in practice some advantage is to be gained by treating as separate units, stocks which do not conform with the basic definition; that is, to assess processes taking place within a unit stock. And in any case it is useful to determine the functional basis of stocks and unit stocks.

The range of a species population includes areas in which its individuals

1. reproduce -- breeding ground,

2. pass through juvenile stages -- nursery grounds,

3. feed and carry on other non-reproductive activities.

In some species these areas cannot usefully be distinguished, in other species two separate areas are distinguishable and in others three or more separate areas can be delimited.

The term "stock transfer" is neutral with respect to direction of movement and consequences thereof, and may be used to signify the movements that take place between incompletely separated stocks and which therefore cannot be regarded as unit stocks.

Classification: Stock transfers may be classified with regard to the following features:

(1) Duration: permanent or temporary; that is, whether the transferred individuals remain with the stock to which they have transferred or may return to the stock from which they moved;

(2) Phase: reproductive, juvenile, non-reproductive adult;

(3) Direction: one way or two way movement; that is, whether there is movement only from stock A to stock B or also from B to A;

(4) Complexity: number of stocks participating;

(5) Composition: whether within a phase (2 above) there is selective movement of sex or age or other group;

(6) Degree of range overlap: two stocks may share a nursery ground or a feeding ground;

Consequences: The consequences of stock transfer will depend upon the character of the transfer as defined by a classification such as the above.

The consequences can be considered under three heads:-

(i) Quantitative: gain or loss, to each stock, in numbers and/or weight resulting in modification of growth, reproduction and mortality.

(ii) Modification of population value of phenotypic characters;

(iii) Modification of genotype.

Research: Investigations may be directed to assessment of the consequences of stock transfer, or to identification of its character or to both. The research may be undertaken to ascertain whether transfer takes place, or to ascertain whether a known transfer is of a significance to call for deeper enquiry, or to make precise measurement of significant transfers.

Each of the methods employed is likely to make some contribution to resolution of these problems, and it seems that a combination of several methods would be required to give effective analysis of a particular situation. Methods directed to analysis of stock composition are unlikely to give a measure of the magnitude and rate of transfers.

Tagging experiments will often be suitable for identifying transfers of classifications 1, 3, 4, and 5 and 6 in part. They cannot help to identify transfers of phase (classification 2), except in the unusual situations in which juveniles are markable and fished, and fish of reproductive phase recognizable externally at the tagging point. Transfers in reproductive phase might be identified by analysis of spawning marks on the hard parts of certain fishes. Transfers in juvenile phase might be appraised if the locations of nursery grounds were better known in relation to the locations of spawning grounds, and

to features of ocean circulation which might cause mixing of separated spawned juveniles on the nursery grounds.

Examples:

A. Pacific Salmon: Although sharing their feeding ground, the separate river stocks separate in the course of the return migrations and eventually reach their home waters.

B. Mullet (*Mugil cephalus*): Unit stocks of this specie exist in the Mediterranean, Florida, Western Australia, Eastern Australia, and elsewhere. For most of each year stock is split into separate populations, each occupying a coastal river-lake system. During autumn there is mixing of these populations during a spawning migration to the sea. The mixing is of a kind to make it impossible to treat the populations in any way other than as a unit stock.

C. Australian Salmon (*Arripis trutta*): This species is present in Australian waters in two sub-species, distinguished by non-overlapping gill-raker counts. One spends its mature life in Western Australian waters, the other spends its mature life in Eastern Australian waters; however, the juveniles (up to 11+) occupy chiefly brackish-water grounds in Tasmania, these nursery grounds being partly shared in common. When the juveniles separate at the onset of maturity there is some transfer which has yet to be measured.

REPORT OF WORKING GROUP 4

Identification of Larvae and Juveniles

Chairman: S. Ueyanagi
Rapporteurs: A. Ronquillo
T. Otsu

The purpose of the Working Group was to examine the various problem areas in the work on identification of eggs, larvae and juveniles of tunas and related species. The importance of positive identification of species at all stages of development from eggs to adults is evident. Although considerable advances have been made in recent years in the identification of larvae and juveniles of the several species, there are areas of disagreement that need to be resolved before further progress can be expected. There is an urgent need to develop a "key to the identification" of the several stages that could readily be used by workers in all parts of the world.

1 Larvae and Juveniles

At the Honolulu Conference two papers were submitted on the identification of tuna larvae.[1/] Both described for the first time for the Pacific the larvae of albacore and bigeye tuna.

The authors of the first paper felt that two types of larvae (Type A = albacore Type B = bigeye) could be distinguished, primarily by locality and time of capture, relative body width, and on the basis of certain pigmentations. The author of the second paper also based his identification on locality and time of capture and on the occurrence of spawning adults in addition to pigmentations on the body. The latter author felt that the "Type A" larvae described in the first paper were actually yellowfin tuna rather than albacore.

1/ Matsumato, W.M., 1962 Identification of larvae of four species of tuna from the Indo-Pacific region. MS presented at the Pacific Tuna Biology Conference, Honolulu, Hawaii, Aug.1961. Paper VII-9. (Published in 1962 by the Carlsberg Foundation as Dana Report No.55, 14 p.)
Abstract in: Spec.sci.Rep.U.S.Fish Wild.Serv.Fish, (415):31

Yabe, H. and S. Ueyanagi, 1961 Contributions to the study of the early life history of the tunas. MS presented at the Pacific Tuna Biology Conference, Honolulu, Hawaii, Aug. 1961. Paper VII-6.
Abstract in: Spec.sci.Rep.U.S.Fish Wild.Serv.Fish, (415):40

After the Conference in Honolulu, continued studies by both workers resulted in agreement on the identification of bigeye tuna but differences still exist with respect to the albacore larvae.

There is need for continuing work on the larvae of *Auxis* and *Sarda* in order that the species can be distinguished. Studies on *Auxis* larvae have not yet resulted in identification below the generic level. According to Fitch and Roedel, (Experience Paper No. 18), there are two valid species of *Auxis*: A. *thazard*, confined to the Pacific, and A. *rochei*, cosmopolitan in distribution. Based on this adult distribution, it should be possible to make species identification in the larvae.

On the question of resolving existing differences in *Thunnus* identification and in furthering our knowledge of the early stages of the several species of *Auxis* and *Sarda*, it was suggested that greater effort be made to effect artificial fertilization in the several species. The difficulties in doing this were apparent but it was noted that some measure of success had been achieved in bigeye tuna by Japanese workers, and that there are probably other species which can be taken in sexually advanced condition suitable for artificial fertilization. It was suggested that preparations be made to take advantage of any opportunity that might arise to do this work.

It was also suggested that a serological diffusion plate study may be of value in distinguishing between the larvae of tuna, such as yellowfin and albacore. It was however pointed out that serological tests should only be used to give supporting evidence and not as the primary tool in identification.

Ueyanagi noted the occurrence of orange pigment spots which are arranged in a seemingly characteristic pattern on the body of yellowfin, albacore, bigeye, and skipjack. These pigment spots, however, fade in a few days after death of the larvae and will keep in formalin for only about three days.

In order to further study this pigmentation pattern, it would be advantageous to collect larval tunas in the viable state. To do this, it is suggested that perhaps a simple perforated bucket (maybe made of plastic) with a "live well" may serve in place of the cod-end sock on a plankton net.

With respect to the juveniles, M.E. Watson (U.S.A.) discussed her work on the albacore and bluefin collected from the Straits of Messina. By using soft X-ray photographs, she was successful in identifying these two species down to a size of about 5 mm. Regarding the procedure used to separate the two species she pointed out that fortunately there are no yellowfin in the Mediterranean Sea and this has simplified separation of the two species considerably. These series should aid in resolving existing differences of opinion regarding albacore larvae.

2 Methods

The group discussed the question of standardizing collection methods. It was agreed that standardization of gear and collection techniques is urgently needed, especially because of the imminent expansion of international oceanic surveys, such as the surveys of the Indian Ocean and the tropical Atlantic.

Tuna larvae are usually sparsely distributed, hence collection methods require straining of rather large volumes of water per haul (circa 1000 m^3). Tuna larvae are distributed primarily in the upper mixed layer, hence their vertical distribution can be completely encompassed by hauls to 200 meters depth. Both of the above requirements can be met by taking oblique tows with a moderately large net (1.0 meter diameter at mouth).

Surface tows taken at night have yielded larger numbers of specimens of tuna larvae than other techniques. When numbers of specimens are a primary need, as in building up larval series, surface tows or similar techniques are recommended as supplements to quantitative oblique hauls.

The need of detailed studies of pigmentation changes during embryonic and larval development was pointed out. It is known in development of *Scombrus* and *Auxis* that melanophores, especially ventral ones, are more numerous on early larvae (under 4 mm.) than on mid-stage larvae, there being a decrease in number by coalescence; late stage larvae again increase the number of melanophores. Because of probable variations in pigmentation with size, it is essential to

carefully define larval pigmentation at all stages of development, preferably by units as small as 0.5 or 1.0 mm. intervals. The studies are the more urgently needed inasmuch as pigmentation is a principal character used in identification of tuna larvae.

The relative importance of larval characters such as pigmentation, morphometrics, meristics, preopercular species, size at which structures differentiate, etc., are not thoroughly enough studied to permit agreement on standardization of identification methods. At the present state of our knowledge of early stages of tunas, varied approaches may bring faster results than a standardized approach. Exchange of "identified" materials from different areas, on a loan basis, was urged as one means of advancing the taxonomy of tuna and other scombroid larvae.

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2	Subpopulation identification	Marr, J.C.
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14	Synopsis of biological data on bigeye tuna *Parathunnus sibi* (Temminck and Schlegel) 1844	Alverson, F.G. and C.L. Peterson
15	Synopsis on the biology of the skipjack *Katsuwonus pelamis* (Linnaeus) 1758 (Atlantic and Mediterranean)	Postel, E.
16	Synopsis on the biology of yellowfin tuna *Thunnus (Neothunnus) albacares* (Bonnaterre) 1788 (Pacific Ocean)	Schaefer, M.B., G.C. Broadhead and C.J. Orange
17	Synopsis of biological data on bluefin tuna *Thunnus thynnus maccoyii* (Castelnau) 1872	Robins, J.P.
18	Synopsis of biological data on bluefin tuna *Thunnus thynnus orientalis* (Temminck and Schlegel) 1842, longfin tuna *Thunnus alalunga* (Bonnaterre) 1788, yellowfin tuna *Thunnus albacares* (Bonnaterre) 1788, and bigeye tuna *Thunnus obesus* (Lowe) 1839 (South Africa)	De Jager, B.
19	Synopsis of biological data on species of the genus *Thunnus* (Sensu lato) (South Africa)	Talbot, F.H. and M.J. Penrith
20	Synopsis on the biology of little tuna *Euthynnus alleteratus* (Rafinesque) 1810 (West Atlantic and Mediterranean)	Marchal, E.
21	Synopsis of biological data on skipjack *Katsuwonus pelamis* (Linnaeus) 1758 (Indian Ocean)	Jones, S. and E.G. Silas
22	Synopsis of biological data on skipjack *Katsuwonus pelamis* (Linnaeus) 1758 (Pacific Ocean)	Waldron, K.D.
23	Synopsis of biological data on albacore *Thunnus alalunga* (Gmelin) 1788 (Western Atlantic)	Idyll, C.P. and D. de Sylva

No.	Title	Author(s)
24	Synopsis of biological data on bonito *Sarda sarda* (Bloch) 1793 (Western Atlantic)	Idyll, C.P. and D. de Sylva
25	Synopsis of biological data on the blackfin tuna *Thunnus atlanticus* (Lesson) 1830 (Western Atlantic)	Idyll, C.P. and D. de Sylva
26	Synopsis of biological data on yellowfin tuna *Thunnus albacares* (Bonnaterre) 1788 (Western Atlantic)	Idyll, C.P. and D. de Sylva
27	Synopsis of biological data on the frigate mackerel *Auxis thazard* (Lacépède) 1802 (Western Atlantic)	Idyll, C.P. and D. de Sylva
28	Synopsis of biological data on the long corseletted frigate mackerel *Auxis thynnoides* Bleeker 1855	Jones, S.
29	Synopsis of biological data on double-lined mackerel *Grammatorcynus bicarinatus* (Quoy and Gaimard) (Indo-Pacific)	Silas, E.G.

EXPERIENCE PAPERS

1	Preliminary experiments with tilapia as bait in the tuna fishery off the coast of Brazil	Gomes da Fonseca, J.B.
2	Investigation of tuna behavior by fish finder	Nishimura, M.
3	Tuna tagging experiments in Norwegian waters	Hamre, J.
4	Measurement of the shape of the tuna longline and an analysis of its efficiency	Hamuro, C.
5	Studies of the reproduction of the bonito *Sarda chilensis* (C. and V.) in Peruvian coastal waters	Chirinos de Vildoso, A.
6	Tunas (genus *Thunnus*) of the Western North Atlantic Part I. Key to the species of *Thunnus* based on skeletal and visceral anatomy	Watson, M.E.
7	Tunas (genus *Thunnus*) of the Western North Atlantic Part II. Description, comparison and identification of species of *Thunnus* based on external characters	Mather, III, F.J.
8	Tunas (genus *Thunnus*) of the Western North Atlantic Part III. Distribution and behavior of *Thunnus* species	Mather, III, F.J.
9	An outline of the tuna longline grounds in the Indo-Pacific (Preliminary Report)	Suda, A., T. Koto, and S. Kume
10	Monofilament gill net fishing for skipjack tuna in Hawaiian waters (A progress report)	Shomura, R.S.
11	Climatic parameters and the Hawaiian skipjack fishery	Seckel, G.R.
12	A method for computing estimates and variances of relative log fishing powers of California albacore vessels	Abramson, N.J.

No.	Title	Author(s)
13	The California albacore fishery logbook system	Craig, W.L.
14	Changes in availability of albacore in the Eastern Pacific Ocean 1952 and 1958	Johnson, J.H.
15	Structure of the albacore stock and fluctuation in the catch in the North Pacific areas	Suda, A.
16	Seasonal and annual variation of the hooking-rate and annual variation of the catch-quantity of tuna and marlin in the tropical Atlantic Ocean	Nakagome, J. and S. Suzuki
17	Distribution of the yellowfin tuna *Neothunnus macropterus* (Temminck and Schlegel) in the tuna longline fishing grounds of the Pacific Ocean	Kamimura, T. and M. Honma
18	A review of the frigate mackerels (genus *Auxis*) of the world	Fitch, J.E. and P.M. Roedel
19	Albacore scouting in the Eastern North Pacific Ocean	Pinkas, L.
20	A method of sampling the Pacific albacore (*Thunnus germo*) catch for relative age composition	Mackett, D.J.
21	California's tuna record-gathering system	Greenhood, E.C.
22	Studies of the erythrocyte antigens of albacore, bigeye, skipjack and yellowfin tunas and their use in subpopulation identification	Sprague, L.M., J.R. Holloway and L.I. Nakashima
23	Tuna landings and production 1916 to 1961	Greenhood, E.C. and S.P. Davis
24	Growth and sexual dimorphism in growth of bigeye tuna (*Thunnus obesus*) A preliminary report	Shomura, R.S. and B.A. Keala
25	Schooling behavior within aggregations composed of yellowfin and skipjack tuna	Yuen, H.S.H.
26	Food of skipjack in the Central Pacific	Waldron, K.D. and J.E. King
27	Effects of water temperature on the distribution of some Scombrid fishes along the Pacific coast of North America	Radovich, J.
28	Distribution of tuna species in the Oceanic Northwest Atlantic	Squire, J.L., Jr.
29	A first examination of the abundance and distribution of yellowfin and albacore tuna in the Western tropical Atlantic, 1957 to 1961	Rodrigues Lima, F. and J.P. Wise
30	Food of Pacific albacore in the California fishery (1955-1961)	Clemens, H.B. and R.A. Iselin
31	A model of albacore migration in the North Pacific Ocean	Clemens, H.B.

No.	Title	Author(s)
32	Species of the genus *Sarda* in the Eastern Pacific	Chirinos de Vildoso, A.
33	Distribution and abundance of tuna related to wind and Ocean conditions in the Gulf of Tehuantepec, Mexico	Blackburn, M.
34	Studies of oceanic fronts in the mouth of the Gulf of California, an area of tuna migrations	Griffiths, R.C.
35	The bonito fisheries in Peru	Ancieta-Calderón, F.
36	The olfactory organ of the skipjack *Katsuwonus pelamis*	Gooding, R.M.
37	The past, present and future status of the tuna resources of the Trust Territory of the Pacific Islands	Wilson, P.T.
38	Thermal relationships of tuna in the oceanic Northwest Atlantic	Squire, J.L., Jr.
39	Food of Indian tunas	Thomas, P.T. and M. Kumaran
40	Spawning of the oceanic skipjack *Katsuwonus pelamis* (Linnaeus) in the Laccadive Sea	Raju, G.

INFORMATION PAPERS

1	A world list of experts concerned with the study of the biology of tunas and related species	Fisheries Biology Branch, FAO
2	Distribution and relative abundance of tunas in relation to their environment	Laevastu, T. and H. Rosa, Jr.
3	Resolutions and recommendations approved by regional tuna meetings 1960-62	Anon.
4	World catch and landings statistics: tunas, bonitos, mackerels, etc.	Gertenbach, L.P.D.
5	A bibliography of research on tunas for the years 1954 to 1956	Van Campen, W.G.
6	A bibliography of research on tunas for the years 1957 to 1961	Bernabei, H.
7	Information on tuna research conducted and planned by the member countries of IPFC and GFCM and by institutions along the West Coast of USA; and specific problems suggested for discussion at the World Scientific Meeting on the Biology of Tunas and Related Species	Fisheries Biology Branch, FAO
8	A world-wide reporting system for tuna fishery statistics	Gertenbach, L.P.D.
9	Resolutions of the Pacific Tuna Biology Conference Honolulu, Hawaii, August 1961. Progress Report	Marr, J.C.

APPENDIX I

RESOLUTIONS AND RECOMMENDATIONS APPROVED BY REGIONAL TUNA MEETINGS 1960 - 1962

	Page
Symposium on Thunnidae Dakar, Senegal, 12 - 17 December 1960	86
Pacific Tuna Biology Conference Honolulu, Hawaii, 14 - 19 August 1961	90
Symposium on Scombroid Fishes Mandapam Camp, India, 12 - 15 January 1962	92

SYMPOSIUM ON THUNNIDAE

DAKAR, SENEGAL, 12-17 DECEMBER 1960

RECOMMENDATIONS

I The Symposium highly appreciates the fact that it has been able to meet in Dakar, a town particularly well suited to the holding of a scientific meeting on tuna, and expresses its deep gratitude to the Government of the Senegal and, in particular, to the Minister for Rural Economy, and the Minister for Planning, and their Services, for the welcome it has received; it also wishes to thank the Institut Français d'Afrique Noire for the facilities made available, and all those who, in various capacities, secretaries, shorthand typists, interpreters, etc. have contributed to its success.

II The Symposium recognizes that views differ among specialists in respect of the concepts of genus, sub-genus and species in the Thunnidae family (sensu lato), and

(a) Notes that from both a scientific and economic point of view (standardization of commercial designations on a clearly defined basis) it is desirable that a solution should be found to this problem;

(b) Agrees, to that end, that a committee of specialists should be established, under the chairmanship of Professor F. Frade (Lisbon), and including Mr. E. Marchal (Abidjan), Dr. F.H. Talbot (Cape Town), Mr. F. Williams (Zanzibar), and Mr. P. Fourmanoir (Nosy Bé);

(c) Recommends that this committee should remain in touch with systematists other than those of Africa but concerned with the same problems;

(d) Requests that this committee should prepare a first report on its work and, if possible on any findings it may have reached, to be presented at the world meeting on tuna, to be organized by FAO in June 1962.

III In view of existing doubts as to the status of genus *Euthynnus* the Symposium recommends that scientific studies should be undertaken by African systematists, particularly those of East Africa and South Africa, because of their geographical position, in order to define exactly the fish under consideration and to classify as species or sub-species the various forms they may encounter.

IV The Symposium notes the different views held by various authors in respect of the growth rates of *Katsuwonus pelamis* and recommends that this matter should be carefully studied in order to achieve satisfactory results.

V In view of the need for biologists and fishermen to identify as exactly and rapidly as possible the populations on which they are working, the Symposium:

(a) Draws the attention of African research workers to the value of serological studies;

(b) Recommends that, in order to avoid false starts and to ensure the standardization of working methods, research workers should adopt the methods at present used by American specialists and described in a number of publications, the bibliographical references of which will be circulated by the Coordinator at a later date.

VI Considering that the geographical areas of distribution of *Thunnus thynnus* and of *Germo alalunga* along the coasts of Africa are still ill-defined, the Symposium:

(a) Requests that all oceanographers marine biologists and fishermen should cooperate in clarifying this problem;

(b) Considers that all captures in the Atlantic, between Cape Blanc (Mauretania) and Cape Frio (Angola), and in the Indian Ocean, north of Durban, of specimens of either species, should be brought to the knowledge of marine biologists;

(c) Considers, however, that such captures can only be taken as scientific proof of the presence of these species if the report is accompanied by photographs or anatomical material providing

unquestionable confirmation of the preliminary identification;

(d) Recommends, therefore, that a number of observations should be made and that information obtained should be carefully investigated before being accepted as valid and final.

VII In view of the information that can be obtained from a thorough study of the fauna associated with Thunnidae (sensu lato) - indicators, competitors, enemies and parasites, the Symposium:

(a) Stresses the importance of this fauna,

(b) Recommends that extensive observations should be made in this field.

VIII The Symposium notes that several species of Thunnidae (sensu lato) are not yet exploited but could be fished, for the benefit of Africa, closer inshore than yellowfin tuna, and

(a) Draws attention to the two most important species among these, i.e. *Katsutonus pelamis* and *Euthynnus alleteratus;*

(b) Recalls that preparations of boiled, dried and smoked *Katsuwonus* are to be found in Japan where they are known by the general name of Katsuwebuschi;

(c) Stresses the food value of these preparations and their popularity among all classes of Japanese society;

(d) Recommends that an effort should be made to introduce their use among African populations;

(e) Suggests that possible outlets should be sought for *Euthynnus* preserved in oil, in airtight tins, on the Mediterranean markets, where they are highly appreciated.

IX In view of the fact that the tuna fishing industry is substantially dependent on the supply of bait for the fishing fleets, the Symposium:

(a) Notes with satisfaction that the Monrovia Meeting has set up a study Committee on Clupeidae;

(b) Requests this Committee to endeavour to establish a preliminary census of resources in *Sardinella;*

(c) Considers that it is desirable that biologists should carry out a comparative study of the various species that can be used as live bait (methods of capture, behavior in tanks, etc.)

(d) Draws attention to the fact that Africa seems to be in a perfect situation to undertake a study of the problem of the use of *Tilapia;*

(e) Recommends that in the field of longlines (with dead bait) a programme of tests should be undertaken with substitute baits, recalling that the fish universally used by the Japanese fishermen, *Cololabis saira*, belongs to the Scomberosocidae.

X In view of the essential part played by thermal fronts in the general distribution of Thunnidae (sensu lato) and in the localization of concentrations sought by the fishermen, the Symposium:

(a) Draws attention to the value of increasing the number of continuous measurements of temperature in regions where tuna fishing is practised;

(b) Recommends for that purpose the use of bathythermographs, and continuous recording thermometers;

(c) Stresses the importance of upwellings and of the thermocline;

(d) Expresses the wish that these concepts be extended among research workers and fishermen;

(e) Recommends, in all events, that their study should be intensively pursued in countries interested in tuna fishing.

XI In view of the value of increased knowledge on the biology of African Thunnidae (sensu lato) both from the scientific and from the practical point of view, and recognizing that tagging has given excellent results in this respect, in other areas and for other species, the Symposium:

(a) Recommends that this method of work should be introduced in the member countries of CCTA/CSA;

(b) Recalls the use of hooks fitted to a breaking leader, and the existence of methods used by the Americans and Norwegians, leaving to the users the choice of the method which seems to them the most adequate;

(c) Thanks the Honolulu Biological Laboratory for its offer to cooperate in this field.

XII The Symposium is convinced that better knowledge of the migratory habits of Thunnidae (sensu lato) found in African waters would contribute to a rational exploitation of these resources.

(a) It recalls the part played by endocrinological factors in determining these migrations;

(b) Draws attention to results achieved in this field with amphibiotic fishes;

(c) Recommends that physiological research should be extended to the holobiotic fishes under consideration.

XIII In view of the value of biometric studies, particularly for the definition of allometric factors and as an approach to the problems of growth and maturation, despite the introduction of more precise methods of identification of populations, the meeting:

(a) Recommends that mensurations carried out on Thunnidae (sensu lato) in African waters should be pursued in the future;

(b) Recommends that a standard method should be adopted in these areas;

(c) Recommends for that purpose the method adopted by J.C. Marr and M.B. Schaefer and described under heading: "Definitions of body dimensions used in describing Tunas", in the Fishery Bulletin, vol. 51, No. 47, 1949, of the USA Fish and Wildlife Service;

(d) Entrusts Dr. F.H. Talbot (South African Museum, Cape Town) and Mr. E. Marchal (Oceanographic Service, Abidjan) which they have agreed to undertake, of working out conversion factors by means of which results obtained in the past, by other methods, may be used in the future in conjunction with work conducted according to the standard method recommended above.

XIV Recognizing that studies conducted on captive Thunnidae are of extreme importance when working on a number of ecological, biological and physiological problems; recognizing moreover that whereas laboratories on coasts of Africa south of the Sahara do not appear to be able to undertake such studies, for a long time to come, research work in this field is actively pursued in other parts of the world; the Symposium stresses the keen interest with which African research workers are following the studies undertaken by American biologists in this field, and expresses the wish that these studies should be actively pursued, for the greater benefit of African countries

XV The Symposium recognizes the need to follow the evolution of stocks of species submitted to extensive commercial exploitation; notes that Thunnidae (sensu lato) found in the Eastern tropical Atlantic, are fished in an ever more intensive manner and,

(a) Draws attention to the necessity of developing the study of the dynamics of their populations;

(b) Considers that this study should be based partly on carefully established statistics;

(c) Requests that consideration should immediately be given to these concepts;

(d) Points out that their implementation raises great difficulties and can only be significant within the framework of investigations conducted in all countries (in and outside Africa) participating in the exploitation of these resources.

XVI The Symposium on Tunas, having regard to the rapidly growing international fishery for tunas in the high seas of the tropical and sub-tropical Atlantic Ocean off West Africa which is being participated in increasingly, not only by the nationals of Africa, but also of European, American and Asiatic countries;

Realizing the necessity of initiating early in the history of this fishery the thorough studies that will be required to provide for the appropriate development of the fishery and the safeguarding of these valuable international resources in accordance with the concepts of maximum sustainable yield set forth in the "Convention on Fishing and the Conservation of the Living Resources of the High Seas" adopted by the Conference on the Law of the Sea convened by the United Nations in Geneva in 1958;

Considering the difficulty, if not impracticability, of any one or few nations being able alone to conduct the research required over such broad stretches of ocean and to gather significant statistics from such a diverse multi-nation fishery;

Being aware of the successful operation for many years of the multilateral "Inter-American Tropical Tuna Commission" in quite similar and complex conditions (tropical and sub-tropical Eastern Pacific Ocean);

Recommends, that CCTA/CSA should take the initiative, either directly or through its member governments, to solicit the convening by the appropriate agency of the United Nations of a conference of plenipotentiaries from all of the nations, both African and extra-African, whose nationals are concerned in the development of these high-seas tuna fisheries and the safeguarding in perpetuity of these resources, for the purpose of establishing among themselves an appropriate agency along the lines of the abovementioned Commission, which will have the functions of (a) collecting statistics of the fishery; (b) promoting large-scale research work on all these resources under consideration; (c) providing member governments with information on the situation and evolution of stocks; (d) formulating such recommendations as may be required to attend to their proper exploitation and conservation.

XVII In view of the need for scientists studying Thunnidae to meet and exchange views and information on the biology of that world resource, the Symposium:

(a) Notes with great interest the arrangements being made by FAO to organize a world scientific meeting on the biology of tunas and related species, to take place in California, USA, during the first half of June 1962;

(b) Draws the attention of scientists to the importance of this meeting;

(c) Agrees that CCTA should be represented at the meeting;

(d) Recommends that all member governments of this organization should give their scientists every facility to contribute to the preliminary work and attend the meeting.

PACIFIC TUNA BIOLOGY CONFERENCE

HONOLULU, HAWAII, 14-19 AUGUST 1961

RESOLUTIONS

1 The Conference recognizes that there are problems in the taxonomy and nomenclature of the tunas and their allies (i.e. Family Scombridae of Fraser-Brunner). The Conference recommends that a review of the family be made on the basis of existing knowledge and submitted to the FAO World Tuna Conference to be held in July 1962. Such a review would serve to identify areas of common agreement and areas requiring further study and material. The Conference requests that Dr. R. Gibbs and Dr. B.B. Collette undertake such a preliminary review.

Realizing that additional specimens of certain kinds and from certain areas will be needed in any case, the Conference recommends that such collections be instituted as soon as possible (the details of kinds and areas to be specified by Dr. Gibbs and Dr. Collette). The Conference requests the U.S. Bureau of Commercial Fisheries Ichthyological Laboratory to explore sources of funds for the collection, shipment and storage of specimens and other associated costs, including study of the material.

The Conference acknowledges with thanks and directs the attention of the Ichthyological Laboratory to the generous offer of Dr. Hiroshi Nakamura, Director, Nankai Regional Fisheries Research Laboratory, to provide specimens from the worldwide Japanese tuna fishery.

2 The Conference recommends that there be established a World Center to promote the exchange of tuna erythrocytes and reagents. The Conference notes that the U.S. Bureau of Commercial Fisheries Honolulu Laboratory volunteers to act in this capacity and requests that it do so.

Further, there is a need to standardize the terminology now in use for tuna blood groups. There is especial need to determine if identical blood groups have been independently discovered and given different names. The Conference recommends that the World Center perform this function and suggests that the concensus of workers in this field be determined regarding standard rules of nomenclature.

3 Realizing that identification of tuna larvae is in such an early stage of investigation and the results are no more than tentative, the Conference recommends that both the Japanese and American researchers continue with their present work until a more definite basis for establishing correct identification of species is attained.

Results of the X-ray method and other internal characteristics would be most helpful to other workers if the species so identified are also described in terms of external characters. The Conference recommends that this be done.

Recognizing the difficulty in capturing the early juvenile stages, the Conference recommends that concerted effort be expended in night-light collecting by all research vessels on a worldwide basis.

4 The Conference recognizes that there remain many problems of population identification and migration and urges all research groups studying tunas to attack these problems through tagging experiments, studies of blood groups, or other appropriate methods. Examples of such studies, but by no means a complete list, include:

A. Tagging small southern bluefin off the south coast of Australia to determine if recoveries are made in the "Old" and "New" fishing grounds to the northwest and west of Australia.

B. Tagging small albacore (less than 50 cm, especially the 35 cm modal group) off Japan, or wherever they may be found, to determine their subsequent movements into the commercial fisheries of the North Pacific.

C. Tagging small-medium albacore

off the west coast of South America to determine if they are subsequently recovered in the longline fishery of the tropical South Pacific.

5 The Conference notes the recent advances in the problems of determining the age of albacore and recommends that those studying this problem work together in resolving uncertainties about the absolute ages to be associated with particular sizes.

6 The Conference points out the substantial advances made in identifying year classes in the North Pacific albacore fisheries and the desirability of studying the individual year-class strength and the individual year-class contribution to the entire fishery with a view to establishing a basis for the study of factors affecting year-class contribution to the entire North Pacific albacore fishery.

7 The Conference recognizes that common attention to taxonomic problems by immunogeneticists, biochemists, and classical taxonomists would be fruitful and requests Dr. A. Suzuki, Dr. R. Gibbs, Mr. G. Ridgway and Dr. L. Sprague (Chairman) to identify problems in tuna taxonomy which could most profitably be so examined, to proceed with such examination insofar as possible and to report their findings to the FAO World Tuna Conference.

8 The Conference recognizes the need for identification of tuna subpopulations, urges those studying blood groups to improve methods for transporting and storing blood samples and suggests that use be made of the wide-ranging tuna fleets of the world in collecting blood samples.

9 The Conference recognizes the importance of genetic identification of subpopulations and urges that additional emphasis be placed on the problem of how much mixing must take place between subpopulations before they are no longer "independent".

10 Studies which bring together research workers engaged in biological and oceanographic studies on the tunas and the seas inhabited by them should be encouraged by international cooperation. Such studies should include, for example, interaction between sea and atmosphere, research on oceanic fronts, water masses, current systems, changing oceanic climates year-class sizes and interaction between fish and environment.

11 In view of the ever-increasing world need for protein and of the rapidly expanding tuna fisheries of the world, attention should be directed to estimates of the magnitude of the world tuna resource and the potential sustained yield of tuna.

12 The Conference agrees that abstracts of submitted papers, summaries of discussion sections, copies of resolutions and a list of participants should be published, if possible, in the Special Scientific Report, Fisheries Series of the U.S. Bureau of Commercial Fisheries, and directs the Chairman to make arrangements for such publication.

Further, the Conference requests the Bureau of Commercial Fisheries Honolulu Laboratory to supply copies of the submitted papers upon request.

13 The Conference recognizes the advantages, especially in promoting the exchange of information and in stimulating the rate of progress in fishery studies, of contact between scientists from different laboratories and suggests that, in addition to scientific conferences, exchange of scientists between laboratories should be facilitated.

14 The Conference recognizes the desirability of a report from this Conference to the FAO World Tuna Conference and directs the Chairman to furnish FAO with copies of all contributions, summary reports of discussions, resolutions and a list of participants.

15 The Conference appreciates the meeting facilities made available by the University of Hawaii and directs the Chairman to prepare a letter of thanks to the University.

SYMPOSIUM ON SCOMBROID FISHES

MANDAPAM CAMP, INDIA

12-15 JANUARY 1962

RECOMMENDATIONS

It is recommended that:

Scientists in the countries of the world primarily concerned with the high-seas fishery for tunas and bill fishes devise and publish a suitable system for gathering biologically useful statistics of yield and effort in these fisheries that will be capable of being employed on a world-wide basis, can be used uniformly by Fishery Officers and scientists everywhere, and that will be capable of yielding data useful in elucidating population dynamics of the several fish populations involved.

It is considered that the devising of this statistical system might be properly initiated at the World Conference on Tunas to be convened by FAO in La Jolla, California, in July 1962.

It is recommended that:

The authorities involved with the planning of the Indian Ocean Expedition give due consideration to gathering and collating the following sorts of information which would be useful in aiding the development of the high seas fisheries for Scombroid Fishes in the Indian Ocean:

(a) Surface temperature charts on a monthly basis particularly from 20° South latitude to the Continent and Island chain on the North;

(b) Variation in thermocline depth with monsoon change particularly within 200 miles of land in the Andaman Sea, Bay of Bengal, Arabian Sea, Persian Gulf and Gulf of Aden;

(c) Variation in direction and flow of the mixed layer currents in the Indian Ocean, particularly North of 20° South latitude, and in particular as related to variation in monsoon period and strength;

(d) Variation in basic biological productivity rate in the area North of 20° South latitude and particularly within 200 miles of shore; and

(e) Relationship of variations in these parameters to variations in the season and yield of the high seas fisheries of the areas.

It is recommended that:

The system of defining the homogeneous stocks of different tuna species, particularly by blood typing as being developed by Japanese and American workers, be extended to a thorough coverage of the tunas and bill fishes of the Indian Ocean.

It is suggested that the collection, care, and shipment of the required samples might be an appropriate function for the Centre of Biological Works to be established at Cochin, in connection with the Indian Ocean Expedition.

It is recommended that:

Appropriate international-agency or agency provide sufficient finances and facilities to permit a competent review on a world-wide basis of the systematics of the Scombroid fishes, together with the publication of the results with all species illustrated in colour.

APPENDIX II

MINUTES OF THE FINAL PLENARY SESSION OF THE MEETING[1/2/]

The Chairman, Mr. Brock, opened the session. He suggested a plan for finalising the participants' report by examining documents or parts of the report dealing with: Meeting machinery; General meeting results; Section and working group reports; Resolutions.

He said editorial corrections should be brought to Mr. Rosa's attention and would be passed to the Editorial Committee. Proposals for substantive changes would be read, comments sought and incorporated if accepted by the meeting. Voting on any given part of the document would be by heads of delegations of countries. He clarified that substantial changes would be adopted by a motion and a vote, and changes without objections would be accepted and incorporated without voting.

Dr. Kesteven suggested the following order of consideration: Chapters I to IV; VII, VI and V. (I, V, VII, VI, IV, III and II) This order was subsequently followed.

The roll was called. Sixteen heads of delegations of the following countries were present: Australia, Chile, France, Germany, Ivory Coast, Japan, Mexico, New Zealand, Norway, Peru, Philippines, South Africa, Spain, United Arab Republic, United States of America, Venezuela.

Mr. Brock explained that participants from international organisations were observers and would have no vote. Captain Audigou declared that he had to leave the meeting before the end of the discussions and proposed therefore to pass his authority to Dr. Postel. Accepted. Dr. Postel read a proxy from CCTA: "You will speak as a representative of the CCTA, which is your official status before the Congress. But, applying the last paragraph under A of Recommendation 16, you will act as the speaker for the Coastal States". Mr. Rosa said FAO would regard Dr. Postel as an observer since he had no official appointment from the Coastal States. Dr. Postel asked that this decision be carried in the minutes.

Chapters I to IV (I, V, VII, VI)

There was no response to Mr. Brock's question whether any substantial changes were proposed to Sections I to IV. (I, V, VII, VI) He said two changes previously in hand would be handled by the Editorial Committee. Sections adopted.

Chapter VII (IV)

Section IA

Mr. Rosa read a suggestion by Dr. Kesteven that Item 2 DISCUSSION be changed to read "The meeting decided to use Methodological Paper IA as a basis for discussion, to amend it in the light of this discussion, and to include the amended version as part of the record of the meeting as a tentative summary of present views of scombroid systematics. The amended paper which is appended hereto therefore is to be considered as part of this report". Section IA was accepted as amended.

Section IB

Dr. Kesteven suggested a rewording for page 104, fourth paragraph (page 34 last paragraph, column 1) slightly amended by Mr. Seid (Van Camp Sea Food Compan to read: "Delimitation and definition of spawning areas on the basis of the occurrence of eggs and larvae can make an important contribution to the solution of the subpopulation problem where a subpopulation is genetically distinct stock of fish. Maintenance of its identity requires spatial or temperal iso-

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1/The draft of this text was submitted for comment to the persons concerned with the discussions.

2/Page references not in brackets refer to the draft report; those in brackets refer to this text.

lation from other subpopulations at time of reproduction". Accepted.

Dr. Postel suggested adding Species Synopsis 20 to the list of synopses on page 101. (33) Mr. Rosa said it would be added.

Dr. Marchal suggested inserting on page 105, third line from the bottom, (page 34, last paragraph, second column) "and the Ivory Coast" to make the sentence read "Off Ghana and the Ivory Coast.....". Accepted.

Dr. Collette suggested weakening the words "almost certain" on page 104, second paragraph. (page 34, third paragraph, first column) Mr. Brock asked Dr. Collette to discuss this with the Editorial Committee.

Dr. Postel suggested that minor changes not affecting the spirit of the document might be written and placed in a box for the Editorial Committee - a technique followed earlier in that session; the Chairman agreed.

Section I was adopted as amended.

Section 2

Mr. Rosa read the following changes suggested by Dr. Schaefer: - page 110, line 8 of penultimate paragraph: (page 36, line 14 of last paragraph, second column) "From the yellowfin studies, one can infer that two population components exist in the area of this fishery, but whether these are genetically distinct populations is an open question".

- page 111, first paragraph: (page 37, second paragraph, first column) add "and yellowfin in the eastern Pacific".

- page 114, line 3: (page 38, line 17 of paragraph 1, first column) delete "during this conference".

These three changes were accepted. Section adopted as amended.

Section 3

Mr. Rosa read a change suggested by Dr. Schaefer on pages 119 and 120 (page 41), Section 2.5: "It should be noted that sex ratio can also depend on differentials in rate of growth or rate of natural mortality between sexes". Accepted. Dr. Schaefer suggested deleting the sentence on page 121, (page 42) Section 2.7, beginning: " Not enough information was available.....". Accepted. Section adopted as amended.

Section 4

Mr. Rosa read a suggestion by Dr. Kesteven that Item 2 DISCUSSION be changed After some discussion and further suggestions by Drs. Schaefer and Ahlstrom, the wording accepted was: "Availability depends on the distribution of fish and on the range of the fishing vessels".

Mr. Rosa read a change proposed by Dr. Kesteven: "Fluctuations in availability are thought to be large in several tuna populations; they elevate production costs in absolute sense and pro rata; they must be allowed for in any studies of abundance; they reflect the response of the population to changes in the oceanic environment and possibly technical changes in the fishing fleet. Their analysis calls for fundamental and comprehensive studies of oceanic and atmospheric features and processes, detailed catch and effort data and the study of certain features of the biology of the species concerned. Such investigations are a prerequisite for the measurement and efficient prediction of changes in availability, required by the fishing industries harvesting them. The forecasts of availability attempted at present are few, empirically-based and predictive only of gross changes". This change was accepted with the stipulation by Mr. Howard that the scientists' interest in such investigations be mentioned.

Mr. Rosa read a suggested change by Dr. Kesteven for the third paragraph following the paragraph just changed, on page 124. (first paragraph, column 2 on page 42) After some debate by Drs. Schaefer, Blackburn and Kesteven, the passage was accepted as follows: "Several investigations have empirically identified the approximate limits of distribution of some tuna populations and related them to surface isotherms. The meeting emphasized, however, that nothing is known about the physiological mechanisms involved, in the reaction of tunas to temperature and continuing observations suggest differences in tuna temperature relations within one species, depending upon locality, age and type of activity (e.g. feeding or spawning). In some instances, the correspondence remains close over changes in the position of the isotherms". Dr. Blackburn suggested the last sentence on page 124 (first paragraph, column 2 on page 42) should

read: "It was emphasized that tuna distribution may be limited". Accepted.

Dr. Schaefer suggested line 3 on page 43 (paragraph two, first column, line 5, page 43) should read:

"It is suggested that the presence of a shoal thermocline.....". instead of "..... there is evidence to indicate that.....". Accepted.

Dr. Kesteven suggested insertion of the following as a paragraph about the heading "4 CO-OPERATION": "Although the meeting was unable to discuss the technical characteristics of fishing units that play a part in determining availability or those characteristics of gear and method that play a part in determining vulnerability, it recognised the importance of these matters and recommended development of research on them". Accepted.

Dr. Talbot suggested some more standard nomenclature to be used for the wide variety of species names used in the table on page 122 (page 40). Mr. Brock agreed that this was a matter of regularizing the names in terms of the amended Methodological Paper. Section adopted.

Section 5

Drs. Schaefer and Kesteven suggested a wording to follow "involved" at the bottom of page 132, beginning a new paragraph: (second paragraph, first column, page 45)

"A suggestion was made that the role of schooling as behavioristic element of the nexus of circumstances determining distribution (both with respect to limits and to density contours) would be worthy of future study. A special aspect of this matter was the length of time in which a school persisted". This was to be followed by the first paragraph on page 134 (page 45), the first part being modified as follows: "With regard to the permanence of a school as a social unit, Australian fishermen fishing bluefin tuna believe that they can follow the same school for an extended period, and tagging results on bluefin tuna from the western side of the Atlantic indicate that the schools maintain themselves for long periods of time". Accepted.

Mr. Rosa read a written comment by Dr. Schaefer, concerning page 133, (page 45) Section 2.3. Dr. Magnuson said he would prefer to revise that part and talk to Dr. Schaefer about it later.

On page 134, line 5, (page 45, column 1, paragraph 3, line 10) Dr. Schaefer suggested adding "and skipjack" at the end of line 5 (line 10). Accepted, but it was left for the Editorial Committee to decide if "or" was preferable to "and".

Dr. Schaefer suggested adding to the first paragraph, page 134: (top of page 45 column 2) "Specimens of yellowfin tuna and of skipjack which have been tagged in each case in the same school have been recovered from several different schools within a few days". Accepted.

Mr. Seid suggested substituting "cook" for "can" on page 136, first sentence, second paragraph. (page 46, first paragraph, second column) Mr. Brock said note would be taken. Section adopted.

Section 6

Dr. Schaefer suggested substituting "great changes in" for "demise of" in the fourth (sixth) line of Section 2.2.2 Pole and Line Fishing. Accepted. In the same line Dr. Ripley suggested changing "their method" to "their operations". Accepted.

Dr. Schaefer suggested adding on page 140 (page 48) "in some areas" after "skipjack", and at the bottom of the page (in the following paragraph) "Spray system have not been proven effective in the eastern Pacific". Accepted.

Mr. Alverson (I-ATTC) suggested making line 4, page 142, (fourth paragraph, second column, page 48) read: "Some bait vessels use trolling to locate schools of fish which are not showing on the surface". Accepted.

Section 6 was adopted as amended.

Section 7

Section was adopted without change.

(Recess)

Section 8, page 152 (page 53)

Dr. Kesteven proposed a change in No. 2, DISCUSSION, page 152, (page 53) 2.1 so that it would read: "Before World War II, the question of tuna (sensu lato), and consequently tuna research was essentially a national question. Since the war, however, the significance of tuna has developed prodigiously and is now a matter of international concern. The consumption of tuna has doubled in ten years, having risen from 400,000 tons in 1950 to 800,000 tons in 1960. It is probable that it will

again double in the present decade. It is with this perspective that research problems must be approached. Oceanographic programs have been drawn up.....". Accepted.

In the third paragraph, page 152 (last paragraph, first column page 53) Dr. Chapman thought "and" after "drawn up" should be replaced by "to be". On Dr. Postel's objection it was decided that the editors would consult the original French text of this paragraph and attempt a better wording.

Dr. Kesteven suggested deleting the first two paragraphs on page 153 (paragraphs 3 and 4, page 53, second column). Drs. Chapman, Schaefer and Postel and Mr. Klawe objected. Dr. Postel said Dr. Kesteven's reasoning would lead to deletion of Section 8 entirely. Dr. Kesteven said that was his fundamental view. He asked the chairman to note his view and said this could hold for the paragraph in the middle of page 153, (page 53, second column) the paragraph at the bottom of page 153 (page 53, second column and top of column one, page 54) and the bottom paragraph of page 154 (page 54, column one) the beginning of the paragraph on page 155 (page 54, column two) and the paragraph on page 156 (page 55) excepting the one marked "a)" on which he wanted to make an observation, and the paragraph on page 157 (page 55). He proposed that the meeting consider only his suggested changes for the top of page 154 (page 55), the title and first paragraph and the paragraph beginning "a)" on page 156. (page 55) Other changes would be covered by his general observations.

Mr. August Felande suggested that paragraph 4, page 153 (paragraph 6, second column, page 53) should read: "By reason of the rapid advance of the undeveloped countries it is probable that in future we shall witness not only the existence of long-range purse-seiners and longliners, but also an increased number of small vessels using various types of gear. Undoubtedly, all types of vessels will use a chain of cold storage plants for transshipment purposes". Accepted.

Dr. Kesteven suggested deleting the first paragraph of page 154,(second paragraph, first column, page 54) sub-title 2.2 and the sub-paragraph, a total of four lines. After some discussion, Dr. Sette suggested this wording: "Following the Chairman's exposition on the major lines developed, the discussion was concentrated on the means of implementing them". Dr. Postel agreed this was sufficiently clear and accurate that both sub-titles could be deleted. This wording and the sub-title deletions were accepted.

Dr. Kesteven suggested that on page 156, Item a)(page 55) under 3, Future research (Future work) the paragraph be deleted after the end of the first sentence. Dr. Schaefer suggested revising it to read: "Should a conflict arise between maximum productivity compatible with stock conservation and financial return from fishing operations, priority should be given to maximum productivity". Accepted.

Dr. Postel noted a translation error on page 156, second paragraph. (page 54, last paragraph, second column) The word "ship-builders" should be "ship-owners", he said. In the third paragraph, second line, (second paragraph, fourth and fifth lines) he suggested inserting "main" between "several" and "ideas". Both changes accepted. Dr. Postel suggested future similar FAO-organised meetings might find it easier not to have a section of the report on Future Lines of Research, but rather to discuss future research within the framework of each section.

Dr. Chapman drew attention to an editorial change in the references for the report of Section Eight which included SS 16 for most purposes. This was noted.

Section was accepted as amended.

Working Group on Stock Transfers

Dr. Schaefer suggested Example A., on page 161 (page 57) Atlantic Bluefin stock, be deleted because of lack of knowledge about this stock. Report accepted as amended.

Working Group on Identification of Larvae and Juveniles

No discussion. Report accepted unchanged.

Chapter VI (III)

Resolution I, The Systematics of Tunas and Related Species, page 46 (8)

Two suggestions were heard: the first from Dr. Talbot and Mr. Fitch; the second from Dr. Postel. The first was to insert the following paragraphs between the paragraphs "TAKES NOTE ...." and "POINTS OUT...."

"NOTES the confusion caused by the use of numerous different generic and specific names in different parts of the world as exemplified by the papers presented at this meeting;

SUGGESTS that Methodological Paper 1A by Collette and Gibbs be used as a tentative outline of scombroid systematics for the stabilization of the nomenclature of the group on a world-wide basis;

FURTHER SUGGESTS that the thirteen generic names within the family Scombridae and the six species named within the genus Thunnus as utilized in Methodological Paper IA to be tentatively accepted pending future revisionary studies."

Dr. Postel's suggestion was that in the paragraph beginning with "NOTES by Dr. Collette, etc.," the Honolulu, Dakar and Mandapam Conferences, and their dates, should be mentioned.

Dr. Schaefer agreed with Dr. Postel and suggested further that the proposed paragraph "SUGGESTS etc.," be placed between the paragraphs "POINTS OUT..." and "RECOMMENDS...".

Me. Brock asked for comments on the proposed changes. There were none.

Drs. Collette and Talbot and Mr. Fitch suggested deleting the words "with all species illustrated in colour" on page 48 (page 9). At Mr. Brock's suggestion, this was left for Editorial Committee decision.

Resolution, as amended, adopted unanimously.

Resolution 2, Definition of Populations by Blood Typing

No comments. Adopted unanimously.

Resolution 3

No comments. Adopted unanimously.

Resolution 4

No comments. Adopted.

Resolution 5

No comments. Adopted unanimously.

Resolution 6

Mr. Saetersdal suggested replacing "them" on page 55, paragraph 6, line 2 (page 11, second column, paragraph 6, line 4) by "monthly records". Accepted.

Dr. Kesteven moved to delete the second paragraph on grounds that it was not essential to the argument concerning statistics presented by the resolution. This amendment was not seconded. Dr. Kesteven wished to record that he accepted the resolution, but with reservation regarding the second paragraph.

Dr. Sette moved adoption of the resolution unchanged. Mr. Ronquillo seconded. Resolution was adopted by show of hands. Mr. Brock suggested a roll call, but no one asked for it.

Resolution 7

The following addition for page 58 (page 12) suggested by Dr. Farris and slightly amended by Dr. Schaefer, was accepted:

"RECOMMENDS FURTHER that the micro distribution of eggs and larvae be studied so that the proper models for statistical estimation may be devised."

Mr. Talbot proposed on page 58 (page 12) again under "RECOMMENDS", replacement of the last sentence after "participating agencies" by "in addition to the necessary development and use of other special gear and methods". Accepted.

Resolution as amended, was adopted unanimously.

Resolution 8

No comments. Adopted unanimously.

Resolution 9

No comments. Adopted unanimously.

Resolution 10

Dr. Marchal suggested using scientific names for "albacore and bluefin" in the title. Dr. Sette suggested using both vernacular and scientific names. Mr. Brock suggested both common and scientific names be used throughout in such cases. Mr. Klawe asked that the scientific name used for bluefin be recorded. Dr. Collette said it would be Thunnus thynnus. Resolution adopted.

Resolution 11

No comments. Adopted unanimously.

Resolution 12

No comments. Adopted unanimously.

Resolution 13

No comments. Adopted unanimously.

Resolution 14

No comments. Adopted unanimously.

Resolution 15

The CCTA observer and the delegate of Japan proposed deletion of the last paragraph "4)" at the bottom of the page and proposed the following wording: "4) Expresses its appreciation to the Secretary General of the CCTA for the actions he has taken in this respect. 5) Asks the Director of the Food and Agriculture Organization of the United Nations to call together at his earliest convenience a planned conference to deal with the matter on a diplomatic level".

Dr. Nakamura asked for it to be recorded that the Japanese scientists' actions should not be taken as indication of a commitment by the Japanese Government to support or participate in the formation of the proposed commission.

Dr. Kesteven said he would neither oppose nor support the suggested change. He asked that the record show his abstention and his previous abstentions.

Mr. Marchal moved to adopt the resolution, as amended; Mr. Rodriguez-Roda seconded. Resolution was adopted by show of hands. Australia, New Zealand, South Africa, United Arab Republic and Venezuela abstaining.

Resolution 16

Dr. Kesteven moved adoption; Mr. Ronquillo seconded. Australia, Chile, Germany, Mexico, Peru, Philippines, South Africa, Spain and Venezuela voted in favor; France, Ivory Coast, Japan, New Zealand, Norway, United Arab Republic, United States of America abstained; none against; Canada, Israel and Senegal did not record a vote. Resolution adopted unchanged.

Resolution 17

Dr. Farris suggested adding to "RECOMMENDS": "RECOMMENDS establishment of graduate and post-doctoral fellowships to attract and support promising biologists to fishery science". He referred to page 5, (page 2) items iv and v, dealing with meeting objectives. Resolution adopted as amended.

Resolution 18

Mr. Rosa suggested adding "and 4" following "... United Nations in the work described in points 3....". Resolution adopted as amended.

Resolution 19

Mr. Brock read the following statement from the delegate of Japan: "The delegate of Japan respectfully comments with respect to Resolution 19 that in instances where it is desired that Japanese scientists serve on the continuing committee, it will be desirable for the Director General of FAO to deal directly with the Government of Japan."

Dr. Sette said the United States delegation would like it recorded that the recommendation is responsive to the suggestion made by the Director of Fisheries Division, FAO of the United Nations, in his address at the opening of the meeting, and responsive to the need of the scientific community for some mechanism for facilitating interchanges and co-operation. Dr. Sette said the United States delegation understood from the language of the latter part of the resolution that the Secretariat provided by FAO might arrange meetings in addition to its other duties. Dr. Sette moved adoption of the reso-

lution; Dr. Postel seconded. Dr. Kesteven moved deletion of everything after "INVITES"at the bottom of page 76 (page 18) and its replacement by "INVITES the Director General of the Food and Agriculture Organization of the United Nations to take steps consistent with the constitutional responsibilities and powers of his organisation to promote and facilitate implementation of the Resolutions of this meeting and suggests that he explore with Governments the desirability of setting up a special committee to assist him in this work. Such a committee should, in the view of the meeting, be small, of about 15 members, and composed of scientists who would act in their individual capacity". Mr. Ronquillo seconded this amendment. Australia, Chile, Mexico, New Zealand, Norway, Peru, Philippines, South Africa and Venezuela voted in favor of the amendment. France, Germany, Ivory Coast, Japan and United States of America against; Spain and United Arab Republic abstained; Canada, Israel and Senegal did not record votes. Amendment carried.

Dr. Sette moved further to amend the paragraph just amended, so that it should read as follows: "INVITES the Director General of the Food and Agriculture Organisation of the United Nations to take steps consistent with the constitutional responsibilities and powers of his organisation to promote implementation of the resolutions of this meeting and SUGGESTS that he explore with Governments the desirability of setting up a special committee to facilitate the implementation of the resolutions of this meeting. Such a committee should, in the view of the meeting, be small (of about 15 members) and composed of scientists who would act in their individual capacities". Dr. Rodriguez-Roda seconded this amendment. Australia, Chile, France, Germany, Israel, Ivory Coast, Japan, Mexico, New Zealand, Norway, Peru, South Africa, Spain, United Arab Republic, United States of America and Venezuela voted in favor of it; none against; no abstentions; Canada, Senegal and Philippines did not record votes. Amendment carried.

Dr. Saetersdal suggested deleting the last sentence of paragraph 3, page 76 (fourth line, first column, page 18) "and for training centers on the collection of catch and effort data". Dr. Sette moved deletion; Dr. Kesteven seconded. Amendment carried.

Dr. Kesteven moved adoption of Resolution 19, as amended; Mr. Ronquillo seconded. Australia, France, Germany, Ivory Coast, Japan, Mexico, New Zealand, Norway, Peru, Philippines, South Africa, Spain, United Arab Republic, United States of America and Venezuela voted in favor; none against; Chile abstained; Canada, Israel and Senegal did not record votes. Resolution adopted as amended.

Resolution 20

No comments. Adopted.

Resolution 21

Mr. Brock read the following resolution, which had not been circulated previously; "The meeting expresses its appreciation to the Director General of the Food and Agriculture Organisation of the United Nations, the staff of the meeting, the local committee, the appropriate officials of the United States, State of California, San Diego and La Jolla, as well as to the Art Center of La Jolla for calling the meeting, for the excellent facilities provided, and for the efficient manner in which the meeting was planned and conducted".

No comments. Adopted.

Resolution 22

Mr. Brock read the following text:

"The meeting, RECOGNIZING the progress made in recent years in developing theories of the behavior of fish populations under exploitation, and statistical and other techniques for treatment of data in conformity with those theories; recognizing the use already made of such theories and techniques in tuna research; BELIEVING that further development of such work is desirable; DRAWS the attention of those engaged in tuna research to the several recommendations contained in the report of Section Three of this meeting; RECOMMENDS that among the responsibilities of the proposed committee on tuna research facilitation should be included the task of promoting appropriate international action in conformity with these recommendations".

Dr. Schaefer hoped that international action would not result in keeping to only those methods used in the recommendations. Drs. Sette and Rodriguez-Roda agreed. Dr. Kesteven assured the meeting that the resolution did not intend a rigid use of any techniques or procedures. He moved its adoption; Dr. Sette seconded. Resolution adopted by show of hands.

(Recess)

General Resolution

Dr. Kesteven moved that the meeting express its appreciation of the very generous hospitality extended to its members, corporately or individually, during the course of the meeting. He requested the Chairman to convey this expression of appreciation to a list of organisations which Mr. Rosa had in his record. Dr. Atilano seconded. Resolution adopted by show of hands.

Chapter V (II) General Results of the Meeting

A number of editorial suggestions by Dr. Farris were passed to the Editorial Committee.

Dr. Schaefer suggested adding the following sentence after "productivity" in line 6, page 40: (last paragraph, second column, page 4) "It has been equally clearly shown that the skipjack in this same region can support a greatly increased fishery". Accepted.

Dr. Schaefer suggested that in the last paragraph on page 44 (page 6, second column) "all" be changed to "several" and "of any sort" be deleted. Accepted.

Mr. Felande suggested adding the following sentence to the first paragraph on page 44: (second column, page 6) "It was recognized, nevertheless, that long-range high-seas fleets will maintain and increase their importance in world tuna production". Accepted.

Mr. Saetersdal suggested the following rewording for line 3, page 45: (five lines from bottom, second column, page 6) "At least ten years of records are needed to estimate adequately maximum sustainable yield". Accepted.

Dr. Talbot suggested replacing "broad" in line 1, page 37 (line 1, paragraph three, second column, page 3) with the following new wording: "Apparently only relatively minor differences of opinion exist". Accepted.

Dr. Saetersdal proposed deleting the last sentence on page 39 (page 4) and inserting the preceding sentence ("The magnitude of....") in the middle of the preceding paragraph on page 39 (page 4) following "basis".

Dr. Schaefer suggested that to make complete the paragraph beginning "The effects of a fishery....", it should read: "That is, a change in the abundance and in the age and size and composition of the population are observed by studying the variations in estimates of population size and examination of the size composition of the catch". Accepted.

Mr. Carry drew attention to the fact that something was missing from page 44, sixth and seventh lines from the bottom. (page 6, sixteen lines from bottom, second column) Mr. Murphy said it was the word "in" in the phrase "in the discussion of size". Accepted. Section adopted as amended.

Dr. Tiews moved a further resolution: "The meeting PLACES on record its appreciation of the efficient and benevelent manner in which the Chairman Mr. Brock, has conducted the proceedings". Dr. Postel seconded. Resolution adopted.

Dr. Sette moved adjournment of the meeting; Dr. Kesteven seconded. The meeting adjourned.

COMPOSITION PARAMETERS OF TUNA STOCKS

Paper Number	Species 6/	Species 1/	Area	4.11 Sex Ratio	4.12 Age				4.13 Size*				Weight**				W = f(l)	L = f(t)	3.15 Fecundity	4.4 Mortality
					Tables and figures	t_r	t_m	t_{max}	l_r	l_m	l_{max}	Tables and figures	W_r	W_m	W_{max}	Tables and figures				
SS 24	Sarda sarda	Sarda sarda	Western Atlantic																	
SS 1	Sarda sarda	Sarda sarda	Atlantic Medit.,etc.	1:1			1-2	V+		39.2	83	Table VI						Table IV	40-50 cm: $7-10 \times 10^5$ 60-70 cm: $1.5-6 \times 10^6$	
SS 3	Sarda orientalis	Sarda orientalis	Indian and Pacific								80				3					
SS 4	Auxis thazard	Auxis thazard	Indian																	
SS 8	Auxis thazard	Auxis thazard	Pacific												?4.5					
SS 21	Katsuwonus pelamis	Euthynnus pelamis	Indian							39	70	Fig.6							42-70 cm: $1.5-2.0 \times 10^6$	
SS 22	Katsuwonus pelamis	Euthynnus pelamis	Pacific	Table X 1:1 but varies			1 or 4	V+		40	85	Fig. 9-11			25			Table, p.3:15	Table IV 61 cm: 8.6×10^5	s = 0.54
SS 15	Katsuwonus pelamis	Euthynnus pelamis	Atlantic and Mediterranean	1:1						45	75				10		$W = 21L^3$ (for fish 2.5-4 kg) 2/			
SS 2	Euthynnus lineatus	Euthynnus lineatus	Pacific							54	64				4.7					
SS 20	Euthynnus alleteratus	Euthynnus alleteratus	W. Atlantic Mediterranean	1:1				X+		40 M 39 F	122						$W = 15.2L^3$ 2/		75 cm: 1.75×10^6	
SS 5	Euthynnus affinis	Euthynnus affinis	Indian	1:1			3-4			50-65	87	Table III			8.6		$W = 1.63 \times 10^{-6} \times L^{3.16}$ 5/	$L_1 = 25$ cm $L_3 = 45-65$ 1/ $L_2 = 25-45$ $L_4 = 65$		
SS 7	Euthynnus yaito	Euthynnus affinis	Pacific	1:1 Table VII						100	60	Table VIII			10					
SS 13	Thunnus saliens	Thunnus thynnus orientalis	Pacific								189				165					
SS 12	Thunnus thynnus	Thunnus thynnus thynnus	Atlantic Mediterranean	1:1.6 Tables			2-3	XVII+		95-105	320			12-17	400-700			Fig. 7	163 kg (VI): 9.4×10^6	
SS 19	T. thynnus thynnus	T. thynnus thynnus	South Africa												360					
SS 19	T. thynnus orientalis	T. thynnus orientalis	South Africa	1:0.6							177									
SS 18	T. thynnus orientalis	T. thynnus orientalis	South Africa	1:1.6				VIII			172				100		$W = 6.394 \times 10^{-5} \times L^{2.92}$ (M) 5/ $= 4.831 \times 10^{-5} \times L^{2.98}$ (F)			
SS 6	Thunnus orientalis	Thunnus thynnus orientalis	Pacific				3?	IX				Table VI		15	230	Fig. 6		Fig. 5, Table V	270-300 kg: 1×10^7	s = 0.57 (adult) s = 0.23-0.34 (young)
SS 17	Thunnus thynnus maccoyii	Thunnus thynnus orientalis	Australia	1:0.7 to 1-22		1	4-5	XII+			110-128	223					$\log x = 2.91 \log y - 4.16$ 3/ Fig.7	Fig. 4	$\log y = 6.4x - 11.4$ 4/	
SS 9	Thunnus germo	Thunnus alalunga	Pacific and Indian	1:0.37 to 1.6 Table X	Fig.17 T. XIII		6	X		F86-90 M90		Fig.14,15, 16,18					Fig. 12a	Tables VIII IX, Fig. 10,11,12	0.8 - 2.6×10^6	s = 0.66
SS 23	Thunnus alalunga	Thunnus alalunga	W. Atlantic																	
SS 19	Thunnus alalunga	Thunnus alalunga	South Africa	1:0.67			?5			85	119						$W = 5.088 \times 10^{-5} \times L^{2.98}$ (M) 5/ $= 3.094 \times 10^{-5} \times L^{2.09}$ (F)			
SS 18	Thunnus alalunga	Thunnus alalunga	South Africa	1:0.5							118				30					
SS 18	Thunnus obesus	Thunnus obesus	South Africa								160				91		$W = 1.8172 \times 10^{-4} \times L^{2.72}$ (M) 5/ $= 1.2810 \times 10^{-4} \times L^{2.79}$ (F)			
SS 19	Thunnus obesus	Thunnus obesus	South Africa								188.5									
EP 24	Thunnus obesus	Thunnus obesus	E. Pacific												235 M 165 F			$W_{\delta M} = 517.8 \ (1-e^{-0.114(t-1.07)})$ $W_{\delta F} = 363.9 \ (1-e^{-0.157(t-1.06)})$		
SS 16	Thunnus (Neothunnus) albacares	Thunnus albacares	Pacific			1.5	2	X+		50			3.4		100-134			Fig. 3		s = 957 - 0.75 (adult-young) s = 0.18 or 7 = 1.72
SS 19	Thunnus albacares	Thunnus albacares	South Africa								166.1									
SS 18	Thunnus albacares	Thunnus albacares	South Africa								156				73		$W = 1.796 \times 10^{-5} \times L^{3.18}$ (M) 5/ $= 8.800 \times 10^{-5} \times L^{2.85}$ (F)			
SS 10	Neothunnus macropterus	Thunnus albacares	Indian			2					190				134			Table VI	Table II $y = 1.25 \times 10^5 \times \frac{x}{(2.9 \times 10^6)}$ 4/	
SS 14	Parathunnus sibi	Thunnus obesus	Pacific		T.IV	3		IX-X			236.4	Fig.5-11		35-46	193		Log W = 2.9034 Log L - 7.116 2/	$L_1 = 45-50$, $L_4 = 115$ 1/ $L_2 = 70$, $L_5 = 138$ $L_3 = 94$, $L_6 = 158$	Table I	
SS 11	Parathunnus mebadi	Thunnus obesus	Indian	1:1				VI-VII		100	239	Fig.8		14-20				Table VI	$2.9 - 6.3 \times 10^6$	
SS 25	Thynnus atlanticus	Thunnus atlanticus	Western Atlantic	1:1 to 2:1													W = 0.01376	$L^{3.10404}$		
SS 26	Thynnus albacores	Thunnus albacares	Western Atlantic												86					
SS 27	Auxis thazard	Auxis thazard	Western Atlantic								39									
SS 28	Auxis thynnoides	Auxis thazard	Indian and Pacific								50-60									
SS 29	Grammatorcynus bicarinatus	Grammatorcynus bicarinatus	Indian and Pacific								100-120									

1/ Intermediate lengths estimated from age determination technique
2/ W stands for weight (in lb.)
L stands for length (in mm)
3/ x stands for weight (in lb.)
y stands for length (in cm)
4/ y stands for gonad weight (in g)
x stands for length L.C.F. (in cm)
5/ w stands for weight (in lb.)
L stands for length (in cm)
6/ As originally listed in the documents
7/ As suggested in Methodological Paper No. 1A of this Report

* Lengths in cm
** Weights in kg
SS Species Synopsis
EP Experience Paper

1.63/E/1/1000